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UNIT IV

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OAC BIOLOGY

UNIT IV

GENETICS

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DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041AaER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1(3.2-3) 41Aa 41Kd
UNIT NUMBER: 04	
UNIT NAME: GENETICS	INSTRUMENT TYPE: ER
TOPIC: Biochemical Genetics	KLOPFER: A.1, A.2, A.3, D.3, D.6
CURRICULAR EMPHASIS: Nature of Science	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: tritiated uracil isotopes RNA DNA

Guideline Objective

The student will appreciate that scientific knowledge develops from experimentation and sense perceptions.

Item Focus

The student will make inferences from experimental data involving radioactive tracer experiments.

Item

It is possible to distinguish RNA from DNA in a cell by labelling DNA molecules with tritiated thymine and RNA molecules with tritiated uracil. (Tritium is the radioactive isotope of hydrogen, ^{3}H.) The idea behind the procedure is that as the nucleic acids are being synthesized, they will incorporate these bases into newly synthesized molecules. The areas where radioactive bases are located can be determined by washing away excess bases which have not been incorporated into nucleic acids, and checking to see which parts of the cell are radioactive. Assume that this technique is used in the following experiment.

Rapidly synthesizing cells were grown in a medium containing tritiated uracil for 1 min, and a small sample was removed from the medium. It was found that the cytoplasm of the sample cells was radioactive. After an additional 5 min, the nucleus, cytoplasm, and ribosomes in the cytoplasm were also radioactive. At this point, the cells were sonicated, fragmented, and the contents centrifuged. The radioactive fractions were analyzed and found to be RNA molecules.

A. What can you infer from the data?

B. What limitations should be put on your inferences?

C. How might this technique be modified so that you could trace the path followed by mRNA?

Response/Marking Scheme

A. Radioactive uracil moves into the cell and is located in the cytoplasm after a period of 1 min. 1

After a period of 5 min, the radioactive uracil is found in the cytoplasm, nucleus, and associated with ribosomes. In this period of 5 min, RNA was synthesized. 1

B. The results do not allow for the inference of where the RNA was synthesized first. 1

Perhaps the RNA was synthesized in all the areas where the radioactivity was found. 1

C. If the time taken between samples was reduced to perhaps 10 second intervals, and if the relative amounts of radioactivity were determined and noted, it might be possible to deduce where the RNA was synthesized in the cell and where it was going. 1 1

Possible: 6

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041AbER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1(3.1-11) 41Ab
UNIT NUMBER: 04	
UNIT NAME: GENETICS	INSTRUMENT TYPE: ER
TOPIC: Genetic Research	KLOPFER: A.1, A.2, A.3, I.2, I.5
CURRICULAR EMPHASIS: Science, Technology and Society	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: genetic disorders genetic counselling issues.

Guideline Objective

Students will be encouraged to develop a commitment to learning about ethical and moral issues that stem from current research and technologies in genetics.

Item Focus

Students will demonstrate an understanding of the contribution made to decisions based on information gained through genetic counselling.

Item

"Nearly 5% of children born each year in Canada have genetic disorders. Also, hereditary diseases account for at least 20% of infant deaths in Canada. Genetic counselling can inform parents of patterns and predictions of the chances of having children with genetic disorders. This information may influence people's decisions to conceive, to abort, to adopt, or even to marry." (*Science Council of Canada*, 1982, p. 18).

A. What does this scientific information contribute to the people involved in making decisions to conceive, abort, adopt, or marry?

B. The aim of prenatal diagnosis is to provide information concerning whether a fetus is normal or abnormal. An underlying assumption is that it is possible to know how to define a defective individual or a life which is not worth saving. How can science become involved in clarifying this assumption?

Response/Marking Scheme

A. Science may provide some important information to people 1

but the decision as to what to do with the information is not a theoretical or scientific decision, it is a practical or an ethical one. 1

Undoubtedly, the bases of the decision will not be scientific, 1

but rather moral, ethical, or economic. The decision ultimately becomes one with which the individuals involved can live confidently. 1

B. The major elements that enter into a decision concerning the worth of a life severely disadvantaged with a genetic disorder lie outside science. 1

Definitions of disorders and of which lives ought not to be saved will probably turn out to be moral, ethical, and legal in nature. 1

Probably the legal definition will prevail. In the final analysis, the decision will be based on an individual's values. 1

Science will probably have little to contribute directly to the decision. 1

Possible: 8

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041AbER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1(3.1-11) 41Ab
UNIT NUMBER: 04	
UNIT NAME: GENETICS	INSTRUMENT TYPE: ER
TOPIC: Genetic Research	KLOPFER: A.1, A.2, A.3, I.2, I.5
CURRICULAR EMPHASIS: Science, Technology and Society	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: medical screening genetic counselling issues genetic disorders

Guideline Objective

Students will be encouraged to develop a commitment to learning about ethical and moral issues that stem from current research and technologies in genetics.

Item Focus

The student will demonstrate an understanding of the implications of genetic counselling.

Item

Medical screening programmes are designed to gather information concerning the genetic conditions of individuals. Tests were devised and used to identify individuals who have not sought genetic counselling, but who might be carrying genes responsible for severe genetic disorders. The individuals themselves may not show any of the symptoms of the genetic disorder in question. Critics of the screening programmes argue that indiscriminant access to this information could endanger personal freedom. Furthermore, some of these critics claim that if there is a right to know, there is also a right not to know.

A. Discuss 2 reasons for individuals wanting to know the results of their own genetic screening.

B. Discuss possible abuses to which information from genetic screening could contribute.

Response/Marking Scheme

A. Some people might wish to know the results in order to reduce their concerns about the possibility of carrying a gene responsible for a disease that may appear later in the individual's life. 1

This could allow for the person to plan for future situations. 1

Some individuals might decide not to have children for reasons of not wanting to pass deleterious genes on to their children. 1

These people might therefore plan to adopt children. 1

B. It is conceivable that some form of compulsory eugenics could be enforced in which the decision to have children might be removed from the individual. 2

Genetic screening might influence insurance companies' decisions 1

could refuse to insure people with possible genetic diseases. 1

People could be denied specific types of jobs 1

(women working with machines such as word processors) on the basis of the possibility of some sort of health danger. 1

Possible: 10

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041AbER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1(3.1-11) 41Ab
UNIT NUMBER: 04	
UNIT NAME: GENETICS	INSTRUMENT TYPE: ER
TOPIC: Genetic Research	KLOPFER: A.1, A.2, A.3, I.2, I.4, I.5
CURRICULAR EMPHASIS: Science, Technology and Society	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: biotechnology recombinant DNA issues genetic engineering

Guideline Objective

Students will be encouraged to develop a commitment to learning about ethical and moral issues that stem from current research and technologies in genetics.

Item Focus

The student will demonstrate an understanding of potential dangers and benefits of research involving recombinant DNA.

Item

Biotechnology, using recombinant DNA techniques, promises to have important beneficial effects on many of our current industrial manufacturing and research processes. However, some people have expressed serious reservations about potentially negative outcomes.

A. Discuss two potentially dangerous outcomes for health and safety, related to research in recombinant DNA.

B. Discuss 3 important benefits that have resulted or may result from biotechnology using recombinant DNA procedures.

Response/Marking Scheme

A. It is conceivable that genes, usually not expressed in organisms, that may have devastating effects on life might be de-repressed and released. Lethal genes might then be expressed. 1

It is possible to splice genes responsible for things such as resistance to antibiotics 1

into microorganisms responsible for diseases and hence create a pathogenic organism with antibiotic resistance. 1

Microorganisms with new capabilities might result, and these might not have natural checks in the environment. 1

B. It is theoretically possible to splice DNA responsible for the production of biologically important compounds into the genome of bacteria such as E. coli, 1

and have the bacteria produce these substances. 1

Substances such as human growth hormone and insulin have been produced. 1

Economically, chemicals such as antibiotics could be produced by microorganisms as a fraction of the present cost. 1

Theoretically, it may be possible to replace faulty genes in utero with properly functioning genes. 2

Possible: 10

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041SaMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Sa
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.10
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA replication	

Guideline Objective

Students will have the opportunity to develop skill in analysing electron micrographs of chromosomes and DNA (deoxyribonucleic acid) molecules.

Item Focus

The student should be able to identify DNA replication in an electron micrograph.

Item

Refer to Figure 4S.1.

ELECTRON MICROGRAPH OF DNA

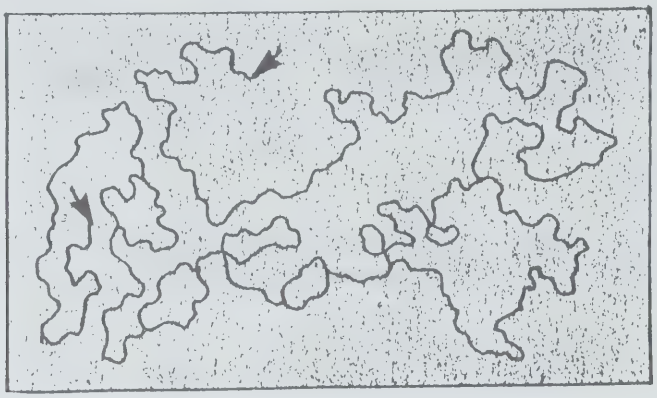


Figure 4S.1 is an electron micrograph showing an actual molecule of DNA undergoing replication. Arrows point to the two ends of the DNA molecule. In how many distinct places can replication be seen to be occurring?

- A. 1
- B. 2
- C. 3
- D. 4
- E. 5

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041SaER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Sa
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.7, A.10, B.1, B.2, D.2, D.3, D.5
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: autoradiograph DNA RNA

Guideline Objective

Students will have the opportunity to develop skill in analysing electron micrographs of chromosomes and DNA (deoxyribonucleic acid) molecules.

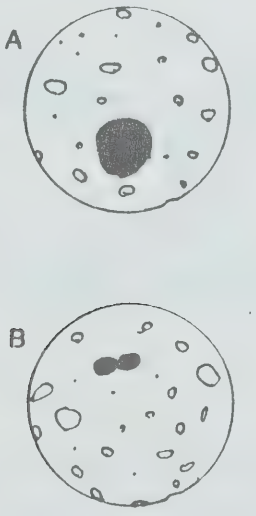
Item Focus

Same as above.

Item

Refer to Figure 4S.2.

AUTORADIOGRAPHS OF TWO CELLS



The accompanying photographs (Figure 4S.2) show autoradiographs of two cells. (An autoradiograph allows the location of a radioactive substance within a cell to be discerned as a very dark patch). The top cell (A) was supplied with radioactive uridine for five minutes before the autoradiograph was prepared. The bottom cell (B) was supplied with radioactive uridine for five minutes, then with non-radioactive uridine for ten minutes before the autoradiograph was prepared.
Account for the differences in the distribution of very dark patches in the two cells.

Response/Marking Scheme

Uridine is found in RNA	1
but not found in DNA.	1
Therefore, it can be used to locate RNA in a cell.	1
In the cell A, transcription was occurring	1
so the uridine (m-RNA) was in the nucleus	1
while, in the cell B, the transcription is using non-radioactive uridine	1
so there is no radioactivity associated with the nucleus	1
but m-RNA transcribed earlier when radioactive uridine was available has moved into the cytoplasm	1
and is likely involved in translation.	1
Possible:	9
Maximum:	7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041SaER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Sa
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Cellular Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: crossing over homologous chromosomes meiosis

Guideline Objective

Students will have the opportunity to develop skill in analysing electron micrographs of chromosomes and DNA (deoxyribonucleic acid) molecules.

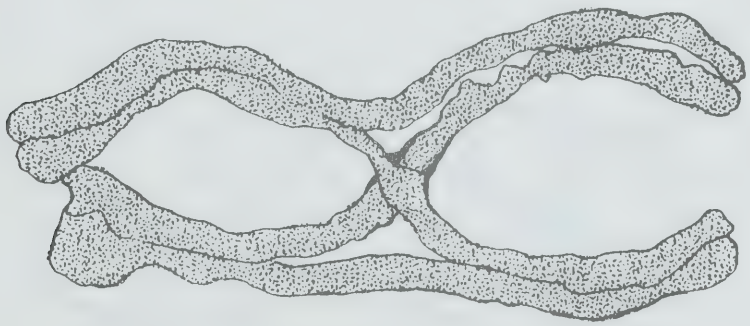
Item Focus

The student should be able to identify crossing over in a photomicrograph of chromosomes, and discuss its biological significance.

Item

Refer to Figure 4S.3.

TWO CHROMOSOMES DURING MEIOSIS



In Figure 4S.3, two chromosomes (chromatids) are shown at one of the stages of meiosis. Identify the process shown, and discuss its biological significance.

Response/Marking Scheme

The process is crossing over (OR synapsis).	1
It permits the exchange of genes	1
between homologous chromosomes,	1
allowing genes from both parents to appear on the same chromosome.	1
This greatly increases the variability among gametes,	1
and partially overcomes the limits to variation imposed by the mechanical necessity to link genes on chromosomes in order to effect efficient nuclear division.	1
Possible:	6
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041SaER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Sa
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Cellular Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: synapsis homologous chromosomes

Guideline Objective

Students will have the opportunity to develop skill in analysing electron micrographs of chromosomes and DNA (deoxyribonucleic acid) molecules.

Item Focus

The student should be able to identify an unusual case of synapsis from a drawing, and explain its meaning.

Item

Refer to Figure 4S.4.

TWO HOMOLOGUES OF A CHROMOSOME UNDERGOING SYNAPSIS

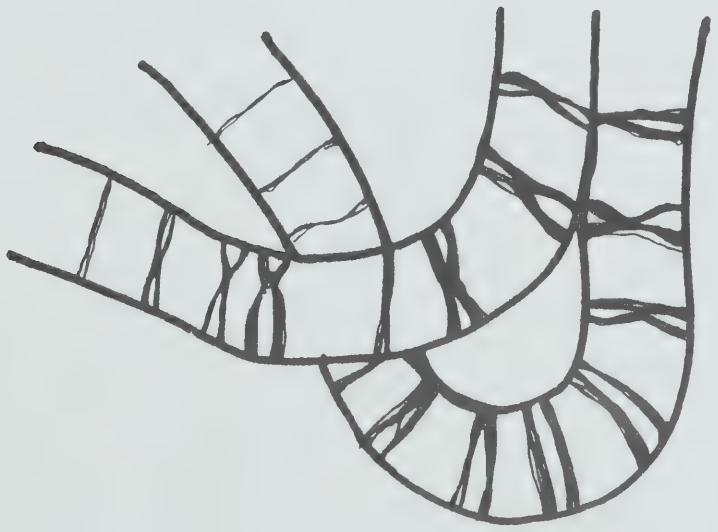


Figure 4S.4 is a drawing of a portion of two homologues of a chromosome undergoing synapsis in a fruit fly cell.

Explain what is unusual about this particular synapsis. Why would this unusual feature be of significance to a scientist doing research in genetics?

Response/Marking Scheme

The lower chromosome is looped	1
instead of lying parallel to its homologue,	1
as would be expected in normal synapsis. It might mean either that some genes have been deleted from the upper	1
chromosome, assuming that the lower one is normal, or	1
there has been duplication of some genes in the lower chromosome.	1
Significance: it would assist geneticists to construct a gene map for the particular part of the chromosome deleted.	1
	Possible: 6
	Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041ScMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Sc
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.10, A.11
TOPIC: Translation	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: transcription replication

Guideline Objective

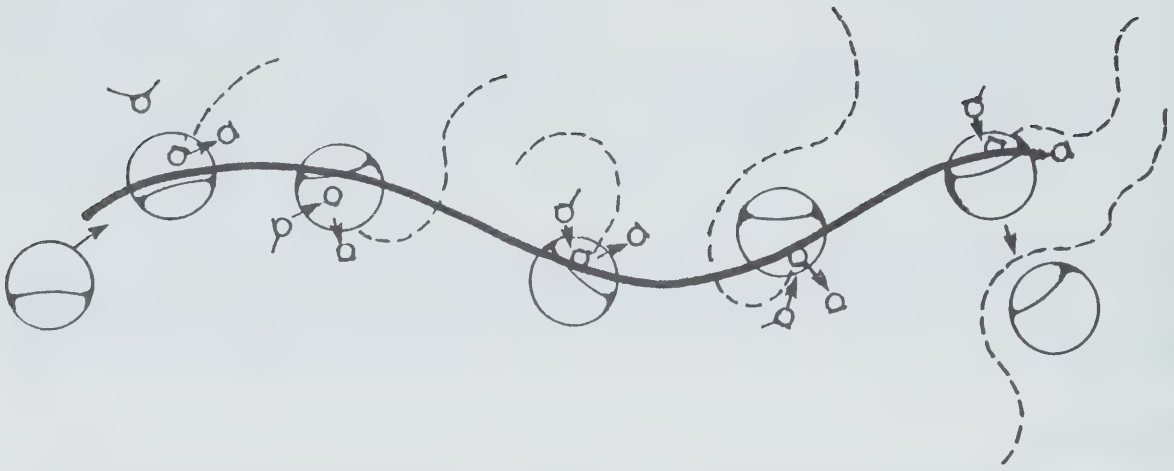
Students will have the opportunity to develop skill in using molecular models to demonstrate aspects of protein synthesis, e.g., the building of m-RNA (messenger-ribonucleic acid), the linkage of t-RNA (transfer-RNA) on m-RNA,and the relationship between m-RNA and the ribosome.

Item Focus

The student should be able to identify a diagrammatic representation of translation.

Item

Refer to Figure 4S.5.



The process depicted in Figure 4S.5 is

- ☐ A. mitosis.
- ☐ B. transcription.
- ☐ C. translation.
- ☐ D. meiosis.
- ☐ E. replication.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KaMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ka
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.4, A.6, A.8
TOPIC: Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: incomplete dominance

Guideline Objective

The students will be expected to recall the meaning of the following terms: gene, allele, dominance, incomplete dominance, meiosis, heterozygous, homozygous, monohybrid and dihybrid crosses, sex linked traits.

Item Focus

The student should be able to identify the concept of incomplete dominance in an example.

Item

'Twas a monk named Mendel, I think,
In search of a filial link,
Crossed a white damsel, 'tis said
With a knight, deepest red,
Their offspring: delightfully pink.

Which of the following is illustrated by the limerick?

☐ A. crossing over

☐ B. mutation

☐ C. natural selection

☐ D. incomplete dominance

☐ E. sex-linked inheritance

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KaSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ka
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.11
TOPIC: Cellular Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: meiosis metaphase II chromosomes

Guideline Objective

The students will be expected to recall the meaning of the following terms: gene, allele, dominance, incomplete dominance, meiosis, heterozygous, homozygous, monohybrid and dihybrid crosses, sex linked traits.

Item Focus

Same as above.

Item

Refer to Figure 4K.1.

DIAGRAM OF AN ANIMAL CELL UNDERGOING MEIOSIS

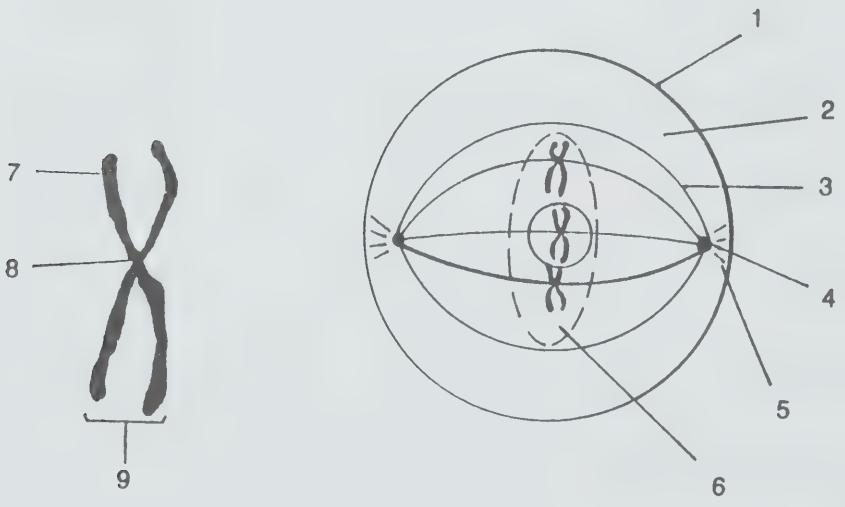


Figure 4K.1 represents an animal cell undergoing meiosis.

A. Name the structures numbered 1 to 9 inclusive.

B. Which phase of cell division is represented by the diagram? Give two reasons for your answer.

C. What was the diploid number of the cell which started the division process?

Response/Marking Scheme

A. 1 - cell membrane (plasmalemma)
2 - cytoplasm
3 - spindle fibre
4 - centriole
5 - aster
6 - equatorial plane
7 - chromatid
8 - centromere
9 - a double-stranded chromosome (2 chromatids) 9

B. Metaphase II 1
- an odd number of chromosomes 1
- arranged across the equatorial plate 1

C. 6 1

Possible: 13

Maximum: 13

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KaSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ka
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.11
TOPIC: Cellular Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: meiosis chromosome

Guideline Objective

The students will be expected to recall the meaning of the following terms: gene, allele, dominance, incomplete dominance, meiosis, heterozygous, homozygous, monohybrid and dihybrid crosses, sex linked traits.

Item Focus

Same as above.

Item

Refer to Figure 4K.2.

ANIMAL CELL UNDERGOING MEIOSIS

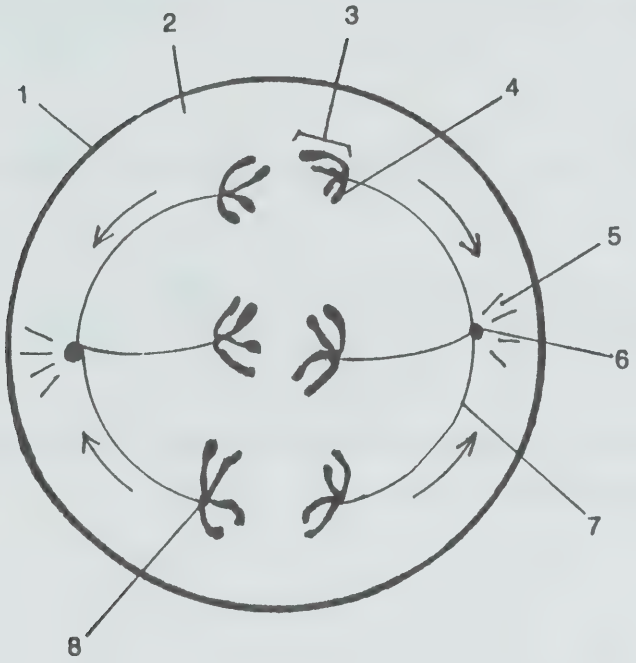


Figure 4K.2 represents an animal cell undergoing meiotic division.

A. Name the structures numbered 1 to 8 inclusive.

B. Which phase of cell division is represented in the diagram?

C. What do the arrows in the diagram represent?

D. What is the diploid number of the cell which started the division process?

Response/Marking Scheme

A. 1 - cell membrane (plasmalemma)
2 - cytoplasm
3 - chromosome (double-stranded)
4 - chromatid
5 - aster
6 - centriole
7 - spindle fibre
8 - centromere — 8

B. Anaphase I — 1
- an odd number of chromosomes, thus meiosis — 1
- chromosomes moving to opposite poles, thus anaphase — 1
- chromosomes double-stranded, thus anaphase II — 1

C. The arrows indicate that chromosomes are being pulled to opposite poles by the contracting spindle fibres. — 1

D. 6 — 1

Possible: 14

Maximum: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA structure	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify the components of a DNA molecule.

Item

Refer to Figure 4K.3.

PORTION OF A DNA MOLECULE

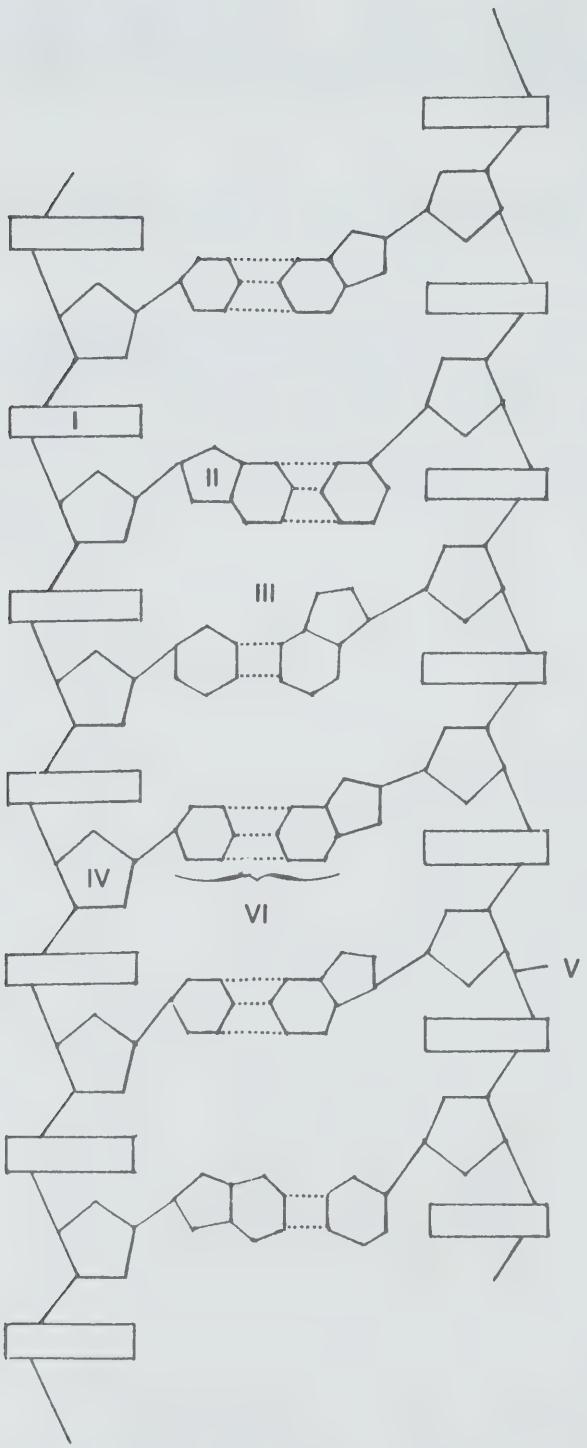


Figure 4K.3 shows a simplified diagram of a portion of a DNA molecule. The parts labelled I, II, III, IV, and V are, respectively

- [ ] A. a nitrogenous base, sugar, phosphate, hydrogen bond, and peptide bond.
- [ ] B. phosphate, nitrogenous base, hydrogen bond, sugar, and phosphate ester linkage.
- [ ] C. sugar, nitrogenous base, covalent bond, phosphate, and amide linkage.
- [ ] D. phosphate, purine, hydrogen bond, sugar, and peptide bond.
- [ ] E. sugar, pyrimidine, hydrogen bond, phosphate, and phosphate ester linkage.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.11
TOPIC: DNA Structure	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: purine pyrimidine

Guideline Objective

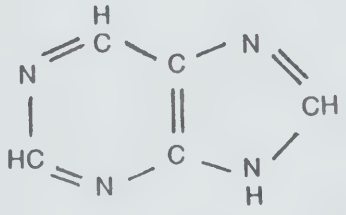
The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify the unit components of a DNA and RNA molecule.

Item

Refer to Figure 4K.4.



The molecule depicted in Figure 4K.4 is a(n)

- ☐ A. sugar.
- ☐ B. nucleotide.
- ☐ C. amino acid.
- ☐ D. purine.
- ☐ E. pyrimidine.

Response/Marking Scheme

Correct response: D

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA purine pyrimidine	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

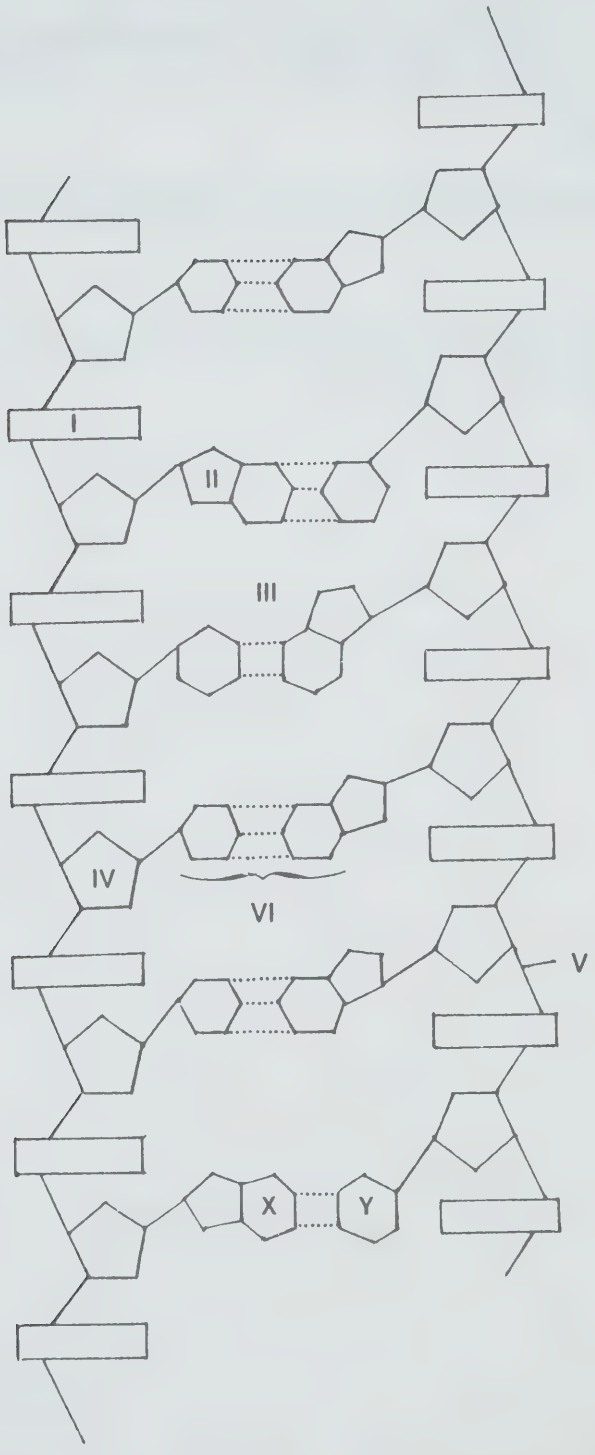
Item Focus

The student should be able to identify the four kinds of nucleic acids in DNA with respect to whether they are purines or pyrimidines.

Item

Refer to Figure 4K.5.

PORTION OF A DNA MOLECULE



In Figure 4K.5, if X is the pyrimidine, cytosine, then Y must be

☐ A. the purine, uracil.

☐ B. the pyrimidine, thymine.

☐ C. the purine, guanine.

☐ D. the pyrimidine, uracil.

☐ E. the purine, adenine.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Composition of Nucleotides	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: nucleotides DNA	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify the component parts of nucleotides.

Item

A specific example of a typical nucleotide may be made up of

- [ ] A. thymine and adenine.
- [ ] B. sugar and phosphate.
- [ ] C. phosphate, sugar, and thymine.
- [ ] D. two phosphate groups, sugar, and thymine.
- [ ] E. thymine, adenine, sugar, and phosphoric acid.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Nucleotide Structure	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: nucleotide DNA RNA

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify the composition of nucleotides.

Item

Which group below represents the composition of a nucleotide found in living cells?

- ☐ A. guanine - glucose - phosphate
- ☐ B. thymine - ribose - phosphate
- ☐ C. cytosine - ribose - phosphate
- ☐ D. uracil - deoxyribose - phosphate
- ☐ E. adenine - ribulose - phosphate

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, C.1, F.1
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify the basic structure of a DNA molecule.

Item

How many guanine bases are present in a DNA molecule 1000 nitrogen base pairs long, if 20% of the molecule consists of adenine molecules?

- ☐ A. 200
- ☐ B. 300
- ☐ C. 400
- ☐ D. 600
- ☐ E. 800

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Location/Function of DNA	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: DNA chromatin

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to associate the presence of DNA with a specific structure within the cell.

Item

In which cell organelle(s) and/or substance(s) listed below, is DNA found?

I centriole
II chromatin
III cytoplasm
IV membrane (plasmalemma)
V ribosomes

Choose your answer from one of the following.

☐ A. I and II

☐ B. III

☐ C. II

☐ D. II and IV

☐ E. I, IV, and V

Response/Marking Scheme

Correct response: C

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify an aspect of the basic structure and function of a DNA and RNA molecule.

Item

The number of molecules of adenine in a given sample of DNA will always be the same as the number of molecules of

- A. deoxyribose.
- B. uracil.
- C. guanine.
- D. thymine.
- E. cytosine.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbMC.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb 41Kc
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Structure of DNA	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: replicate nucleotide Watson-Crick

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to identify the feature of DNA that accounts for its ability to reproduce specific nucleotide sequences as it replicates?

Item

Which feature of the Watson-Crick DNA model accounts for the ability of DNA to reproduce specific nucleotide sequences as it replicates?

- ☐ A. Sugar and phosphate molecules are lined together to form the "up-rights" of the "ladder".
- ☐ B. "Ladder-rungs" composed of ribose alternate with "ladder-rungs" composed of deoxyribose.
- ☐ C. A given nucleotide will usually link with only one other kind of nucleotide in forming a "rung".
- ☐ D. The structure of the molecule is like a spiral ladder with the "uprights" composed of specific nucleic acids.
- ☐ E. Each nucleotide attracts another exactly like itself to form a mirror image of its half "rung".

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbEE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: EE
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:
KEYWORDS: DNA structure	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

Same as above.

Item

Describe, in words only, the structure of a DNA molecule.

Response/Marking Scheme

The DNA molecule consist of two strands	1
which are linear (unbranched) and twisted around one	1
another to form a helical molecule.	1
The strands have identical backbones made up of alternating deoxyribose and phosphoric acid residues	2
joined by dehydration synthesis.	1
The two strands run in opposite directions,	1
$5' \longrightarrow 3'$ and $3' \longrightarrow 5'$.	1
These portions are towards the outside of the molecule.	1
The interior consists of nitrogen-containing bases	1
linked to deoxyribose in a dehydration synthesis.	2
Hydrogen bonds between bases on opposite 'backbones'	1
hold the two strands together	1
but the bonding is weak compared to the covalent bonds	1
elsewhere in the molecule. Only four different bases	1
occur in DNA. They are the purines, adenine and guanine	1
and the pyrimidines, thymine and cytosine.	1
A purine in one backbone is always accompanied by pyrimidine in the opposite backbone.	1
This is necessary for spatial reasons.	1
Because of differences among the bases in numbers and	1
polarities of hydrogen bonding sites,	1
adenine is always linked to thymine	1
and guanine to cytosine.	1
Thus, adenine/thymine and guanine/cytosine are referred to as complementary pairs of bases.	1
	Possible: 25
	Maximum: 20

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KbER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kb
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Structure of Nucleotides	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: nucleotide	

Guideline Objective

The students will be expected to describe the molecular structure and configuration of DNA.

Item Focus

The student should be able to list the component parts of nucleotides, and explain the variety of ways that these can be linked together by condensation reactions.

Item

A. List eight possible chemical "building blocks" that can be found in natural nucleotides.

B. Using a single example, show how the "building blocks" combine to form a nucleotide.

C. Name (initials are acceptable) six other possible nucleotides that could arise when the process shown in part B uses the different "building blocks" listed in part A

Response/Marking Scheme

A. adenosine, cytosine, guanine, thymine, uracil, ribose, deoxyribose, phosphate (or phosphoryl or phosphoric acid) (8 @ 0.5 marks each)	4
B. Example, showing correct relationship between the building blocks, and	1
naming two condensation sites	2
C. Any six of: AMP, CMP, GMP, TMP, UMP, dAMP, dCMP, dGMP, dTMP, dUMP (6 @ 0.5 mark each)	3
Maximum:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KcMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kc
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: DNA Replication	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA	

Guideline Objective

The students will be expected to describe the process of DNA replication.

Item Focus

The student should be able to identify the reason for precise replication of the DNA molecule.

Item

The precision with which a DNA molecule usually replicates is primarily due to the

- ☐ A. energy supplied when ATP undergoes a conversion to ADP.
- ☐ B. bonding of certain purines with certain pyrimidines.
- ☐ C. presence of genes.
- ☐ D. spacing of the phosphate bonds in the double helix structure of the DNA molecule.
- ☐ E. the presence of only five kinds of nucleotides.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KcMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kc
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.5
TOPIC: Genetic Code	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA replication	

Guideline Objective

The students will be expected to describe the process of DNA replication.

Item Focus

The student should be able to identify the coding of bases in the replication of DNA.

Item

If the base sequence in DNA is AATCGG, what is the sequence of the complementary chain?

- [ ] A. TTGCAA
- [ ] B. TTAGCC
- [ ] C. UUAGCC
- [ ] D. CCATUU
- [ ] E. TTUGCC

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KcER.01R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kc
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: DNA replication	

Guideline Objective

The students will be expected to describe the process of DNA replication.

Item Focus

Same as above.

Item

Describe how the gene segment, $\underset{\text{TAG}}{^{3'\longrightarrow 5'}}$ would be replicated during the cell cycle.

Response/Marking Scheme

During the S-phase of the cell cycle, some unknown stimulus would cause separation of	1
the TAG segment from its complement.	1
Free nucleoside triphosphates floating in the cytoplasm	1
would be able to come in contact with the exposed bases. A nucleoside triphosphate would form hydrogen bonds with	1
its complement among these exposed bases.	1
Thus, a free dATP would align with the exposed "T",	1
free dTTP with the exposed "A"	1
and free dCTP with the exposed "G". The newly aligned	1
nucleoside triphosphates would then be joined,	1
phosphoryl group of one to a sugar hydroxyl group of an adjacent one	1
in a reaction catalyzed by DNA polymerase with	1
free energy being provided by the simultaneous hydrolysis of two high energy phosphoryl-phosphoryl bonds.	1
This would continue through both original strands of DNA.	1
Afterwards, there would be two DNA molecules, each containing one of the original strands of the parent DNA	1
and one newly-synthesized complementary chain,	1
with the nucleotides ATC running in $5' \longrightarrow 3'$ direction.	2
The molecule would spontaneously twist into a double helix	1
with the hydrophylic portion towards the outside	1
and the hydrophobic stacked bases inside.	1
Possible:	21
Maximum:	16

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Biochemical Genetics
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KcLA.01R
GUIDELINE OBJECTIVE CODE: 41Kc
INSTRUMENT TYPE: LA
KLOPFER: A.1, A.2, A.3, A.7, A.9, C.2, D.1, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: DNA replication

Guideline Objective

The students will be expected to describe the process of DNA replication.

Item Focus

The student should be able to interpret the data from an experiment involving the synthesis of radioactive DNA.

Item

In an experiment, the same volume (0.3 mL) of a standard reaction medium (containing 1 μ mol of magnesium chloride, 20 μ mol of buffer at pH = 9.2, and 3 μg of "enzyme fraction VI") was added to 5 mμ mol of radioactive deoxyribocytosine triphosphate (the phosphoryl group attached to the deoxyribose was "labelled" with radioactive phosphorus, ^{32}P), shown as dCTP*.

In each trial, the reaction mixture was incubated at 37°C for 30 min; then the DNA was collected by precipitation, and the quantity of radioactive DNA was determined. In four of the five trials, 10 μg of pre-formed, non-radioactive DNA was added. In trials 2, 3, and 4, 5 mμ mol of non-radioactive deoxynucleoside triphosphates were added, as shown in the table below. Account for the results shown in the table.

Trial	Pre-formed DNA added?	Deoxynucleoside triphosphates added	Radioactive DNA precipitated (mμ mol)
1	no	dCTP*	0.0
2	yes	dCTP*, dGTP, dTTP, dATP	3300.0
3	yes	dCTP*, dGTP, dTTP	15.7
4	yes	dCTP*, dGTP	5.1
5	yes	dCTP*	2.5

Response/Marking Scheme

Trial 1 shows that pre-formed DNA is necessary (primer)	1
acting as a pattern (template) for synthesis of new DNA.	1
Trial 2 is a control, showing the amount of new DNA that can be synthesized in 30 min if all the nucleosides are present.	1
Trials 3 to 5 show that only small quantities of new DNA can be synthesized when the nucleosides in the reaction mixture are limited.	1
As soon as a deoxynucleoside not in the reaction mixture is required by the template,	1
the elongation of the new DNA chain stops.	1
As expected, the less diversity there is among deoxynucleoside triphosphates in the reaction mixture,	1
the sooner the elongation of new DNA must stop.	1
Possible:	8
Maximum:	6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KdMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kd
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Location of RNA	DIFFICULTY LEVEL: `L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: RNA ribosome	

Guideline Objective

The students will be expected to describe the structural and functional relationship between DNA and RNA.

Item Focus

The student should be able to associate RNA with specific structures within the cell.

Item

In which cell organelle(s) and/or structure(s) listed below, is RNA found?

I centriole
II chromatin
III cytoplasm
IV membrane (plasmalemma)
V ribosomes

Choose your answer from one of the following.

☐ A. I and II

☐ B. III

☐ C. II

☐ D. II and IV

☐ E. II, III, and V

Response/Marking Scheme

Correct response: E

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Transcription
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KdER.01
GUIDELINE OBJECTIVE CODE: 41Kd 41Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: messenger RNA transfer RNA DNA

Guideline Objective

The students will be expected to describe the structural and functional relationship between DNA and RNA.

Item Focus

Same as above.

Item

A. Contrast the relative length and structure of messenger RNA (m-RNA) molecules with those of the DNA molecule from which it was transcribed.

B. Explain why the DNA code is similar but not identical to the code on transfer RNA (t-RNA)?

C. Describe two factors that determine the specificity of the transfer RNA (t-RNA) molecule?

Response/Marking Scheme

A. The mRNA are shorter because they carry only a part the DNA specifications, enough to assemble one polypeptide. 1

They are single-stranded instead of double-stranded. 1

B. Because, while both are the complementary strand of the mRNA, 1

tRNA uses the base uracil in place of the base, adenine. 1

C. A different anti codon (3 nitrogenous bases) attracts each tRNA molecule to the mRNA strand. 1

It has a unique specific 3-dimensional shape that permits an enzyme to combine it with the appropriate amino acid. 3

Possible: 8

Maximum: 5

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Gene Functions
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: differentiation mitosis

INSTRUMENT CODE: B041KdER.02
GUIDELINE OBJECTIVE CODE: 41Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The students will be expected to describe the structural and functional relationship between DNA and RNA.

Item Focus

The student should be able to explain why different genes are activated in different tissues even though all the somatic cells of a particular organism carry the same set of genes.

Item

Although all the somatic cells of a particular organism carry the same set of genes, in different tissues different genes are activated.

A. By what mechanisms are the genes in all cells of an organism the same?

B. By what mechanisms do different tissues differ in their structure and functions even though they have the same gene complexes?

Response/Marking Scheme

A. During mitosis, each chromosome, with its full	1
complement of genes is replicated, and every somatic	1
cell receives an identical set.	1
B. In specific cells, the cell environment may be different.	1
Cell environments influence the cell membrane	1
which in turn transmits information to the proteins	1
forming the regulator part of the gene,	1
to turn on/off specific genes.	1

Possible: 8

Maximum: 6

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KdSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kd
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.11
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: codon RNA DNA amino acids

Guideline Objective

The students will be expected to describe the structural and functional relationship between DNA and RNA.

Item Focus

The student should be able to describe the structural relationship between DNA and RNA.

Item

Consider the following information:

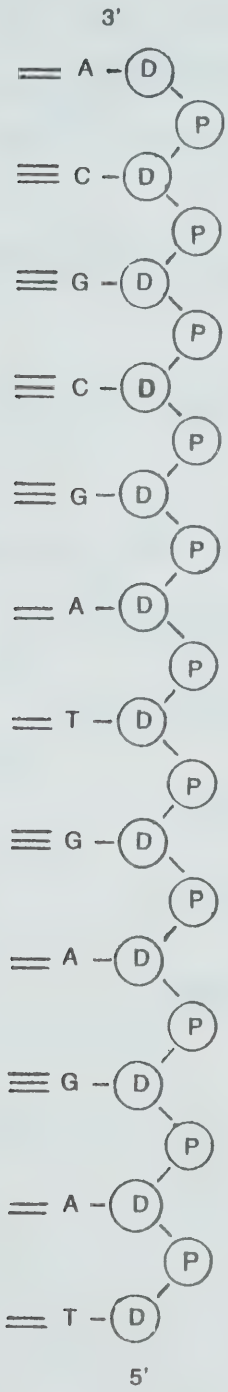
amino acid	mRNA codon $5' \longrightarrow 3'$	
phenylalanine	UUU	Note: These are
cysteine	UGC	only representative
alanine	GCU	codons; more than
glycine	GGU	one codon specifies
threonine	ACU	for the same amino
leucine	CUA	acids.

Diagram the part of the strand of a DNA molecule that contains the information for the following sequence of amino acids:

cysteine-alanine-threonine-leucine.

Indicate the $3'$ and $5'$ end of the strand, and give the meaning of the symbols used, including the letters of the nitrogen bases. Draw in the hydrogen bonds that bond this strand to its complementary strand.

Response/Marking Scheme



D - deoxyribose sugars

P - phosphate groups

A - adenine

C - cytosine

G - guanine

T - thymine

3' - 5'

nitrogen base sequence

hydrogen bonds

nitrogen base sequence

hydrogen bonds

Possible: 10

Maximum: 10

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Structure of Nucleic Acids
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KeMC.01
GUIDELINE OBJECTIVE CODE: 41Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: DNA RNA

Guideline Objective

The students will be expected to compare the structure of DNA and RNA.

Item Focus

The student should be able to identify a difference in structure between DNA and RNA.

Item

One difference between DNA and RNA is that

- [ ] A. the carbohydrate parts of the two molecules differ.
- [ ] B. DNA contains nucleotides while RNA has nucleosides.
- [ ] C. the positions of the phosphate bonds differ.
- [ ] D. DNA contains guanine and RNA does not.
- [ ] E. RNA forms a double helix while DNA is single.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KeMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ke
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Structure of Nucleic Acids	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: DNA RNA

Guideline Objective

The students will be expected to compare the structure of DNA and RNA.

Item Focus

The student should be able to identify a difference in structure between DNA and RNA.

Item

In which of the following would you find adenine bonded to thymine and cytosine bonded to guanine?

- ☐ A. nucleotides
- ☐ B. nucleosides
- ☐ C. RNA only
- ☐ D. DNA only
- ☐ E. both RNA and DNA

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Nucleotide Structure
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KeMC.03
GUIDELINE OBJECTIVE CODE: 41Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.7, C.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: RNA

Guideline Objective

The students will be expected to compare the structure of DNA and RNA.

Item Focus

The student should be able to identify differences between DNA and RNA.

Item

A research scientist hopes to trace the movement of messenger RNA through cells using radioactively labelled RNA in a technique called autoradiography. The best compound to feed to his test animals to induce them to manufacture radioactively labelled messenger RNA within their cells would be radioactively labelled

- [ ] A. thymine.
- [ ] B. guanine.
- [ ] C. cytosine.
- [ ] D. uracil.
- [ ] E. adenine.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KeER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ke
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: DNA RNA

Guideline Objective

The students will be expected to compare the structure of DNA and RNA.

Item Focus

Same as above.

Item

Compare the molecular structures of DNA and RNA.

Response/Marking Scheme

DNA consists of double complementary strands whereas RNA is a single strand.	2
The DNA molecule is held by hydrogen bonding	1
in a twisted helical shape	1
whereas RNA is of variable shapes or has hydrogen bonding	1
only between complementary base sequences of the single chain.	1
Both DNA and RNA contain phosphodiester linkages between	1
nucleotides and may contain the bases adenine, guanine, and cytosine among their nucleotides,	1
but the sugar part of the nucleotides differs,	1
(deoxyribose in DNA, ribose in RNA),	1
and uracil occupies the position in RNA that would be	1
occupied by thymine in DNA.	1
Some types of RNA also have unusual bases modified in the cell following transcription.	1
Possible:	13
Maximum:	10

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Biochemical Genetics
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: DNA RNA

INSTRUMENT CODE: B041KeSA.01
GUIDELINE OBJECTIVE CODE: 41Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The students will be expected to compare the structure of DNA and RNA.

Item Focus

The student should be able to compare the structure of DNA and RNA.

Item

List five differences and two similarities between DNA molecules and RNA molecules in eukaryotic cells.

Response/Marking Scheme

Differences:

DNA molecules	RNA molecules	
-double stranded	-usually single stranded	1
-deoxyribose sugar	-ribose sugar	1
-contains thymine (no uracil)	-contains uracil (no thymine)	1
-can replicate	-cannot replicate	1
-restricted to nuclei, mitochondria, chloroplasts (not found in cytoplasm of mature cell)	-found in both nucleus and cytoplasm of mature cell	1
-inheritable	-not inheritable	1

Similarities:

Both contain the nitrogen bases guanine, cytosine, and adenine. 1

The nucleosides (nitrogen bases and pentose sugars) of both molecules bond with phosphate groups to form chains of nucleotides. 1

Possible: 8

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Biochemical Genetics
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: nucleotide DNA RNA

INSTRUMENT CODE: B041KeSA.02
GUIDELINE OBJECTIVE CODE: 41Ke
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The students will be expected to compare the structure of DNA and RNA.

Item Focus

The student should be able to describe the structure of nucleotides, and the differences between DNA and RNA.

Item

A. List the three primary components of nucleotides.

B. State three differences between the structure of DNA and that of RNA.

Response/Marking Scheme

A. nitrogen base, pentose sugar, phosphate group (or phosphoryl group) 3

B. Accept any three valid contrasts, such as

DIFFERENCE	DNA	RNA	
pentose sugar	deoxyribose	ribose	2
no. of strands	2	1	2
nitrogen base	thymine	uracil	2

Possible: 9

Maximum: 9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KfMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kf
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Transcription/Translation	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: DNA RNA

Guideline Objective

The students will be expected to explain in general terms how the genetic information encoded in DNA controls the activities of the cell and the growth and development of the organism.

Item Focus

The student should be able to identify nucleotides that carry identical codons.

Item

Which of the following most closely resembles the sequence of bases in a particular triplet of the DNA code?

- ☐ A. messenger RNA.
- ☐ B. transfer RNA.
- ☐ C. the new protein produced.
- ☐ D. ribosomal DNA.
- ☐ E. the chain of anti-codons.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KfMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kf
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: anticodon codon transfer RNA messenger RNA

Guideline Objective

The students will be expected to explain in general terms how the genetic information encoded in DNA controls the activities of the cell and the growth and development of the organism.

Item Focus

The student should be able to identify one of the major stages in protein synthesis.

Item

The process by which the anticodons on the transfer RNA molecules match their complementary codons on the messenger RNA molecules is called

- ☐ A. transcription.
- ☐ B. translation.
- ☐ C. transpiration.
- ☐ D. replication.
- ☐ E. translocation.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KfMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kf
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.10, A.11
TOPIC: Genetic Code	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: gene polypeptide	

Guideline Objective

The students will be expected to explain in general terms how the genetic information encoded in DNA controls the activities of the cell and the growth and development of the organism.

Item Focus

The student should be able to apply the 3:1 correspondence rule between DNA and polypeptides.

Item

Refer to Figure 4K.7.

THE AMINO ACID SEQUENCE OF
A POLYPEPTIDE HORMONE FROM CATTLE

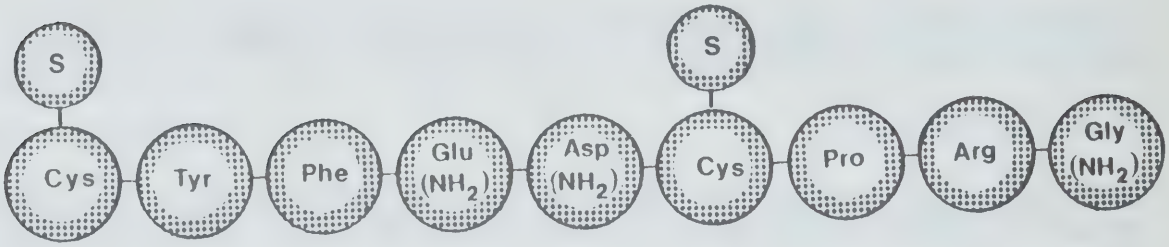


Figure 4K.7 shows the amino acid sequence of a polypeptide hormone from cattle. Disregarding "START" and "STOP" information, and assuming no changes have been made in it since translation, the number of bases in the gene that directs the formation of this polypeptide would be

- A. 3.
- B. 4.
- C. 8.
- D. 9.
- E. 27.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KfER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kf
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.10, D.3, D.5
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: DNA RNA transcription

Guideline Objective

The students will be expected to explain in general terms how the genetic information encoded in DNA controls the activities of the cell and the growth and development of the organism.

Item Focus

The student should be able to interpret experimental results in terms of the transcription of DNA.

Item

Refer to Figure 4K.8.

THE ASTRACHIN AND VOLKIN EXPERIMENT

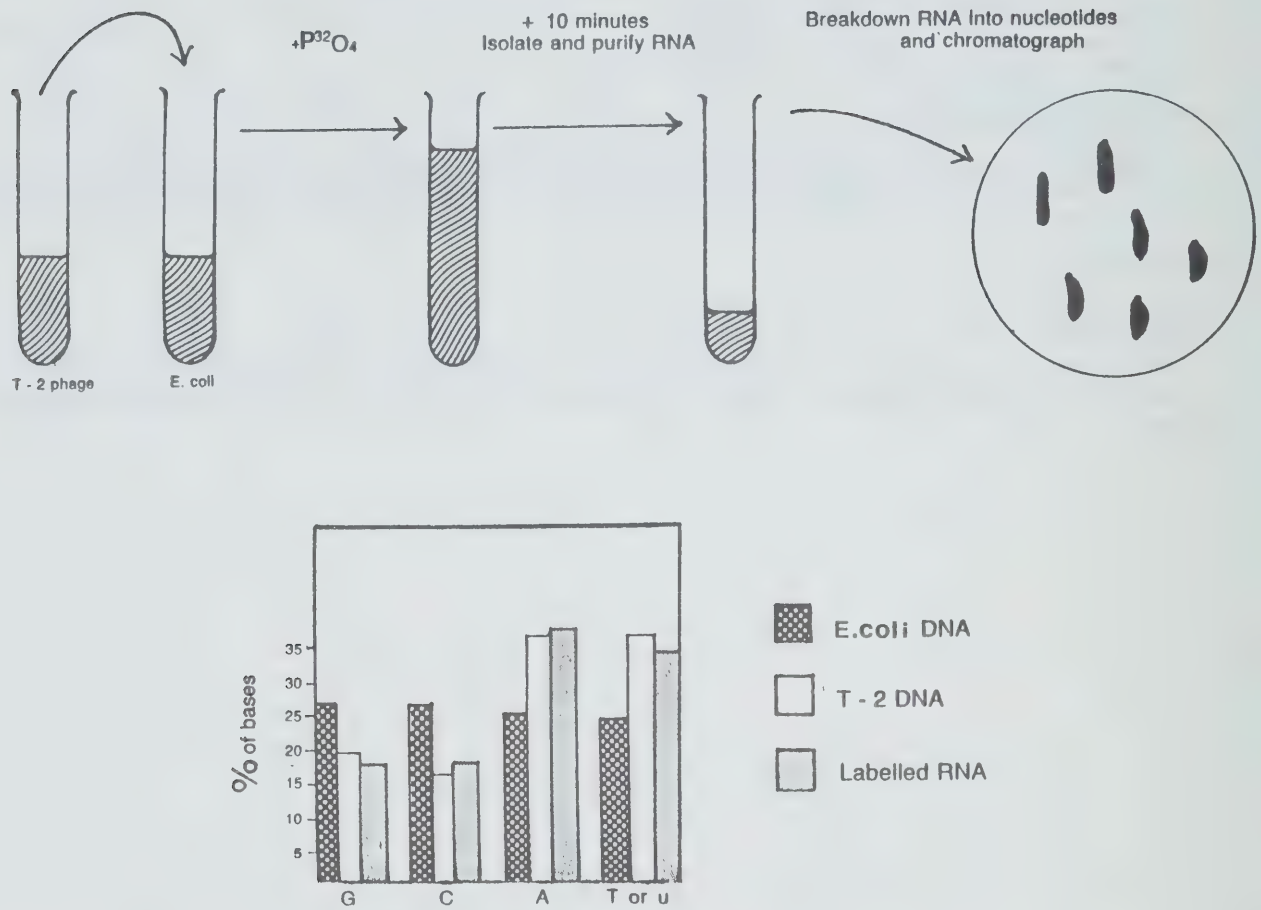


Figure 4K.8 illustrates in pictorial form the experiment of Astrachin and Volkin. They exposed bacteria (*E. coli*) to a virus that infects them (T-2 phage) for 10 min in the presence of radioactive phosphate. Then they obtained radioactive RNA from the preparation, hydrolyzed it, and compared its base composition to that of the DNA of both *E. coli* and T-2 phage. The results are shown graphically.

A. State the hypothesis that the experimenters probably were testing in this experiment.

B. Evaluate the results in terms of the hypothesis.

C. What control experiment(s) should have been performed but are not shown in the figure?

Response/Marking Scheme

A. The virus uses the bacterial cell's metabolism 1
to transcribe its own DNA. 1

B. Since the nucleotides formed after injecting phage 1
are similar in proportion of bases to that of phage 1
and very different from the proportion in *E. coli* 1
it seems very likely that they arose from the transcription of phage DNA,
therefore the evidence supports the hypothesis. 1

C. Controls should be run in the experiment, using T-2 phage alone, 1
and using *E. coli* alone. 1

Possible: 8

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: RNA enzyme	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the function of molecules of RNA in the cell.

Item

If an enzyme (RNA-ase) that facilitates the breakdown of RNA were introduced into a cell, the function that would be affected first would be

- ☐ A. glycolysis.
- ☐ B. replication of DNA.
- ☐ C. formation of ATP.
- ☐ D. protein synthesis.
- ☐ E. breakdown of lipids.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: transfer RNA	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the function of transfer RNA.

Item

In the process of protein synthesis, transfer RNA (t-RNA) functions by

- [ ] A. attaching messenger RNA (mRNA) to the ribosomes.
- [ ] B. joining correctly positioned amino acid into new RNA.
- [ ] C. delivering amino acids to the messenger RNA.
- [ ] D. carrying RNA from the DNA to the ribosomes.
- [ ] E. converting proteins into amino acid molecules.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KgMC.03
GUIDELINE OBJECTIVE CODE: 41Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: DNA polypeptide

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to describe the numerical relationship between the nitrogenous bases on a strand of DNA and the amino acids of a polypeptide.

Item

What is the mininum number of nitrogenous bases in the part of a DNA strand which codes for the 32 amino acids making up a polypeptide?

- [ ] A. 16
- [ ] B. 32
- [ ] C. 64
- [ ] D. 96
- [ ] E. 128

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: transcription messenger RNA DNA

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the name of a major step in protein syntehsis.

Item

The process by which messenger RNA is synthesized from a DNA template is called

- ☐ A. transcription.
- ☐ B. translocation.
- ☐ C. replication.
- ☐ D. transpiration.
- ☐ E. translation.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: protein synthesis translation RNA	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the site of protein synthesis.

Item

The cell structure where most of the protein synthesis takes place is the

- ☐ A. cell wall.
- ☐ B. nucleus.
- ☐ C. nucleolus.
- ☐ D. nuclear membrane.
- ☐ E. ribosome.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: transfer RNA tRNA

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the role of tRNA in translation.

Item

The most likely minimum number of different varieties of transfer RNA (tRNA) that would be necessary for a cell's survival is

- ☐ A. 1.
- ☐ B. 3.
- ☐ C. 4.
- ☐ D. 20.
- ☐ E. 64.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Structure of tRNA	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: transfer RNA	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

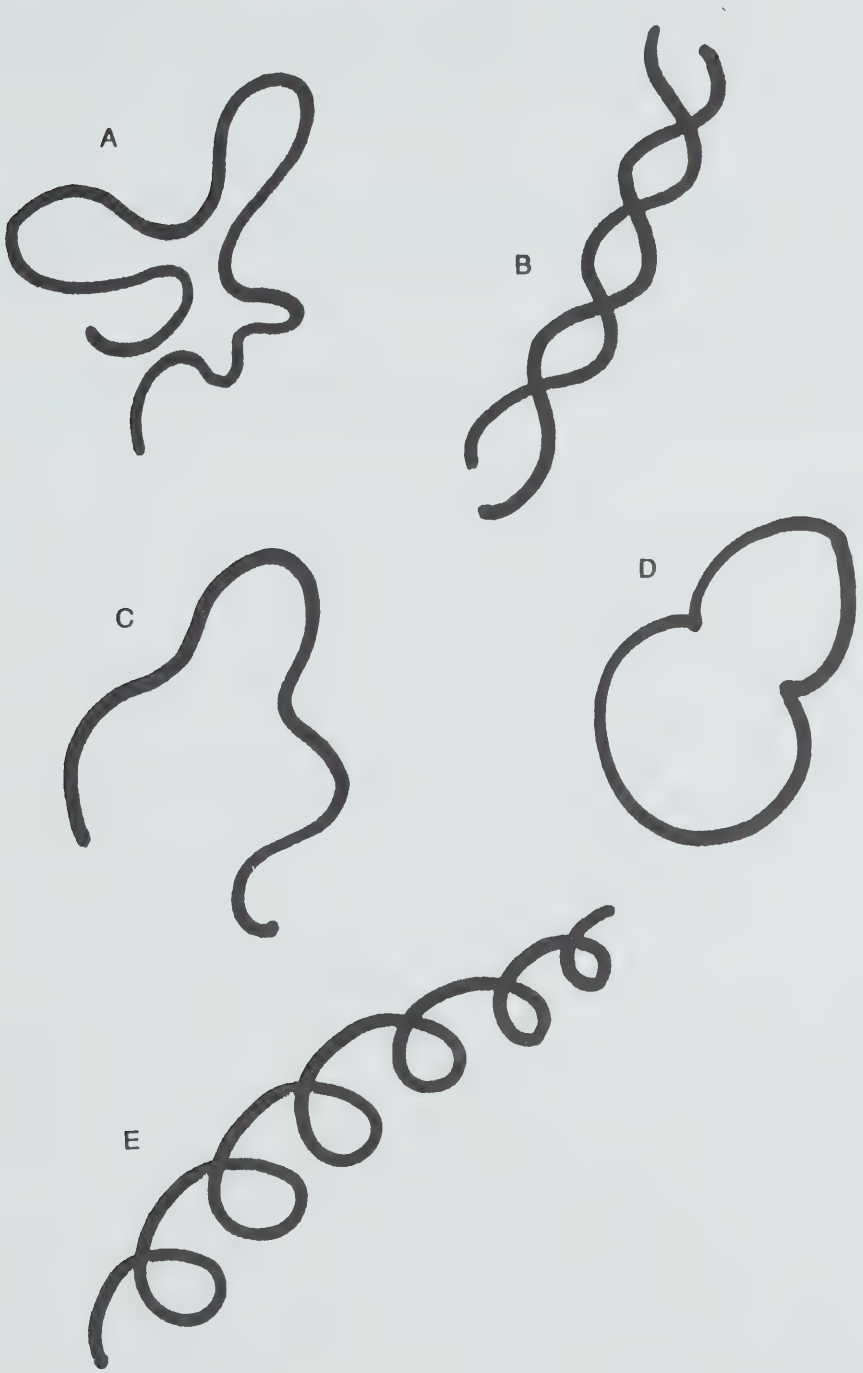
Item Focus

The student should be able to identify the standard diagram depiction of transfer RNA.

Item

Refer to Figure 4K.9.

THE STRUCTURES OF NUCLEIC ACIDS



Which diagram in Figure 4K.9 best represents the structure of transfer RNA (tRNA)?

- [ ] A. A
- [ ] B. B
- [ ] C. C
- [ ] D. D
- [ ] E. E

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: ribosome

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the site and mode of synthesis of proteins.

Item

Proteins are synthesized

- ☐ A. in the nucleus.
- ☐ B. at the ribosomes.
- ☐ C. from polymerized nucleotides.
- ☐ D. from polysaccharides.
- ☐ E. as a double helix of amino acids.

Response/Marking Scheme

Correct Response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, C.2, F.1
TOPIC: Transcription	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: amino acids anticodon	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the basic structure of a DNA and RNA molecule.

Item

The anticodons of arginine, serine, and tyrosine are GCA, UCA, and AUA respectively. If a segment of DNA codes for these three amino acids in the sequence listed (argenine, serine, tyrosine), which of the following would be the sequence of nitrogen bases in the part of one of the strands of the DNA molecule which coded for those amino acids?

- [ ] A. GCATCAATA
- [ ] B. CGUAGUUAU
- [ ] C. CGATGTAUA
- [ ] D. GCAUCAAUA
- [ ] E. CGTUCAAUA

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Transcription	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: complementary strand

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the basic structure and function of a DNA and RNA molecule.

Item

If the sequence of nitrogenous bases in a segment of a strand of a DNA molecule is

guanine(G), adenine(A), thymine(T), adenine(A), cytosine(C) and guanine (G),

then the sequence of bases in the complementary strand of messenger RNA would be

- ☐ A. C U A G U C.
- ☐ B. G C U U A C.
- ☐ C. C U A U G C.
- ☐ D. C T A T G C.
- ☐ E. G A U A C C.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.11
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Transcription	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: messenger RNA transfer RNA anticodon codon

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the basic structure and function of the codons in protein synthesis.

Item

A transfer RNA molecule carrying the amino acid, serine, has the anticodon UCA. The complementary codon on the molecule of messenger RNA would be

- [ ] A. UGA.
- [ ] B. TGU.
- [ ] C. AGU.
- [ ] D. AGT.
- [ ] E. UCA.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.12
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.5
TOPIC: Genetic Code	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: messenger RNA protein synthesis

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the amino acid called for in protein synthesis by a particular codon.

Item

Refer to Figure 4K.10.

TABLE OF MESSENGER RNA CODONS

first letter \ second letter	U	C	A	G	third letter
U	UUU, UUC: phe UUA, UUG: leu	UCU, UCC, UCA, UCG: ser	UAU, UAC: tyr UAA: stop UAG: stop	UGU, UGC: cys UGA: stop UGG: tryp	U C A G
C	CUU, CUC, CUA, CUG: leu	CCU, CCC, CCA, CCG: pro	CAU, CAC: his CAA, CAG: gln	CGU, CGC, CGA, CGG: arg	U C A G
A	AUU, AUC, AUA: ileu AUG: met	ACU, ACC, ACA, ACG: thr	AAU, AAC: asn AAA, AAG: lys	AGU, AGC: ser AGA, AGG: arg	U C A G
G	GUU, GUC, GUA, GUG: val	GCU, GCC, GCA, GCG: ala	GAU, GAC: asp GAA, GAG: glu	GGU, GGC, GGA, GGG: gly	U C A G

The base triplet on the DNA is TAC. From Figure 4K.10, it can be seen that this codes for the amino acid

- ☐ A. glycine.
- ☐ B. methionine.
- ☐ C. lysine.
- ☐ D. tyrosine.
- ☐ E. histidine.

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.13
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: translation tRNA	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the mechanism of translation.

Item

During translation, a transfer RNA (tRNA) molecule is associated with

☐ A. an amino acid, a messenger RNA molecule and a ribosome.

☐ B. an amino acid molecule, a DNA molecule, and a ribosome.

☐ C. an amino acid, a DNA molecule, and a ribosome.

☐ D. a DNA molecule, a messenger RNA molecule, and a ribosome.

☐ E. an amino acid, a ribosome, and a nucleolus.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KgMC.14
GUIDELINE OBJECTIVE CODE: 41Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: protein nucleus ribosome

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the form of nucleic acid involved in a particular step of protein synthesis.

Item

During the synthesis of proteins in cells, coded information is carried from the nucleus to the ribosomes by

- [ ] A. transfer RNA.
- [ ] B. amino acids.
- [ ] C. part of a strand of DNA.
- [ ] D. ribosomal RNA.
- [ ] E. messenger RNA.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.15
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: translation ribosome amino-acetyl-tRNA

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to describe the structure of tRNA and relate the importance of a specific tRNA forming a chemical bond with a specific amino acid.

Item

In the translation of genetic information into proteins, ribosomes must unite temporarily with

- ☐ A. DNA and tRNA.
- ☐ B. amino-acetyl-tRNA and mRNA.
- ☐ C. DNA and mRNA.
- ☐ D. DNA and amino-acetyl-tRNA.
- ☐ E. bases with nitrogen and 5-carbon sugars.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgMC.16
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: amino acids proteins nucleic acids

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to identify the molecule that determines the sequence of amino acids in a protein.

Item

The precise sequence of amino acids in a protein is determined by

- ☐ A. a nucleotide sequence.
- ☐ B. its tertiary structure.
- ☐ C. the location of disulphide bridges.
- ☐ D. another protein.
- ☐ E. the hydrogen bonds.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.5, A.9, A.11
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:

KEYWORDS: messenger RNA transfer RNA

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

Same as above.

Item

Using notes and simple diagrams, outline the process by which amino acids are assembled into polypeptides according to the coded message from the nucleus. Include in your explanation the role of transfer RNA and messenger RNA.

Response/Marking Scheme

Diagram: 5

Labels:

cytoplasm
DNA
amino acid
ribosome
mRNA
tRNA with amino acid attached
tRNA (freed from its amino acid)
peptide chain (or protein being assembled) any 6

mRNA contains the complementary code to the DNA 1
mRNA moves from the nucleus to the ribosome. 1
mRNA moves through the ribosome's active site. 1
One by one, tRNA molecules, each with one specific amino acid attached, are attracted to the ribosome, 3
where they match their anticodon with a codon on the mRNA 1
and enzymes attach their amino acid to the forming peptide chain. 1

Possible: 19

Maximum: 15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgER.02R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1 to 3, A.7, C.2, D.3, D.5, E.5, E.6
TOPIC: Biochemical Genetics	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: chromatography amino acids genetic code

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

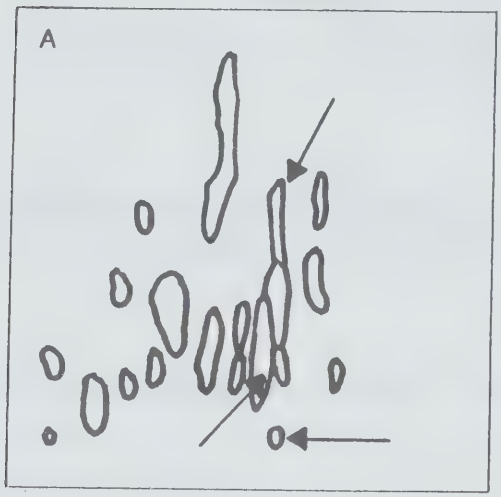
Item Focus

The student should be able to interpret experimental evidence and evaluate hypotheses regarding the genetic code.

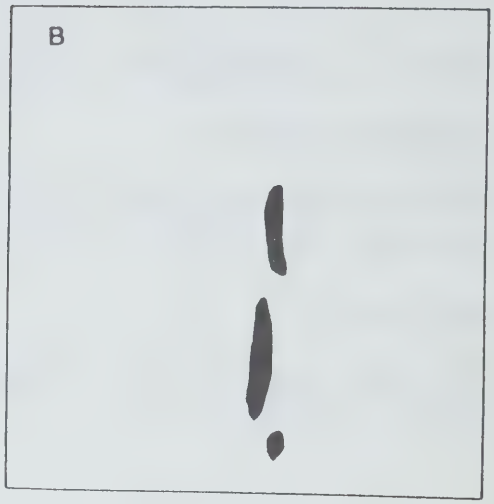
Item

Refer to Figure 4K.11.

2 - DIMENSIONAL CHROMATOGRAM
OF PEPTIDES OF RABBIT HEMOGLOBIN



AUTORADIOGRAM OF PEPTIDES
OF RABBIT HEMOGLOBIN



HYPOTHETICAL AUTORADIOGRAM OF
PEPTIDES OF RABBIT HEMOGLOBIN

Lipmann and von Ehrenstein experimented in 1961 with rabbit cells that develop into red blood cells, and do little else except manufacture hemoglobin (reticulocytes).

Figure 4K.11-A shows a chromatogram of peptides formed when rabbit hemoglobin is digested by the enzyme, trypsin. Careful analysis revealed that the peptides marked with arrows were the only ones that contained the amino acid, leucine.

Polyribosomes were isolated from rabbit reticulocytes, and mixed with cytoplasm (which included no organelles) from bacteria that had been supplied with the amino acid, leucine, which had been labelled with radioactive carbon. This mixture manufactured hemoglobin which was then analyzed by the methods described in paragraph 2, except that a autoradiogram of the chromatogram was prepared. Figure 4K.11-B shows the result. It is possible to identify the peptides that are labelled with radioactivity.

A. Interpret the results. How do these results support current theories about the universality of the genetic code?

B. Suppose that, instead of obtaining the result shown in Figure 4K.11-B, Lipmann and von Ehrenstein had obtained the hypothetical autoradiogram in Figure 4K.11-C.How would the theories about the genetic code have had to be modified? Explain your reasoning.

Response/Marking Scheme

A. Because the radioactive spots coincide with the spots in 4K.11-A that contain leucine, we conclude that bacterial cytoplasm contains the transfer RNA (tRNA) molecules that respond to the same genetic code (mRNA)

provided by the rabbit polyribosomes. 2

Therefore the genetic code may be universal, if organisms as distant as bacteria and rabbits share it. 1

B. In Figure 4K.11-C, only one of peptides known to contain leucine is labelled. 1

Three other labelled peptides were known not to contain leucine when rabbit cells made hemoglobin. 1

Therefore, the bacterial leucyl-tRNA would have interpreted the rabbit mRNA differently, and built leucine into other peptides of hemoglobin. 1

By chance, the one peptide that coincided with Figure 4K.11-A may have the labelled leucine substituting for one of its other peptides. 1

In this case, it would have appeared that bacteria and rabbits differed in their genetic code. 1

This conclusion would have been contrary to our current theory that the genetic code is universal, that the same code is used by all living organisms. 1

Possible: 9

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: DNA RNA metabolism

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to describe information flow in living cells.

Item

Briefly explain the role of the following in directing metabolism within the cells.

A. DNA,
B. RNA (three types)
C. protein

Response/Marking Scheme

A. DNA (any 2 marks)

carries information directing cell machinery how to — 1

construct vital proteins, and does so in a relatively stable (long-lived) form — 1

that can be precisely copied when nuclei divide. — 1

B. RNA (any 6 marks)

brings together amino acids in a sequence directed — 1

by the information of DNA.

Messenger RNA (m-RNA) carries a transcribed copy — 1

of the DNA message into the cytoplasm in a temporary form. — 1

Ribosomal RNA (r-RNA) is an important component of — 1

ribosomes, binding the m-RNA, and involved in the — 1

joining of amino acids.

Transfer RNA (t-RNA) carries amino acids to the — 1

ribosomes, and aligns them with other amino acids — 1

as directed by the information on the m-RNA.

C. Protein (any 2 marks)

has the most direct connection with metabolism. Proteins include the

enzymes needed to cause chemical — 1

reactions to proceed at a suitable rate. — 1

Regulator proteins act as chemical switches, — 1

activating and repressing genes — 1

controlling the flow of information about metabolism. — 1

Possible: 15

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: transfer RNA translation

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student should be able to describe the structure and functions of transfer RNA.

Item

A. Describe how a tyrosine transfer RNA (t-RNA) molecule functions during protein synthesis.

B. Draw a simple line diagram of the cloverleaf model of a tyrosine tRNA molecule. Indicate the functions of the different parts of the molecule and write in as many nitrogen bases as possible, given that a codon for tyrosine is 5′UAC3′.

Response/Marking Scheme

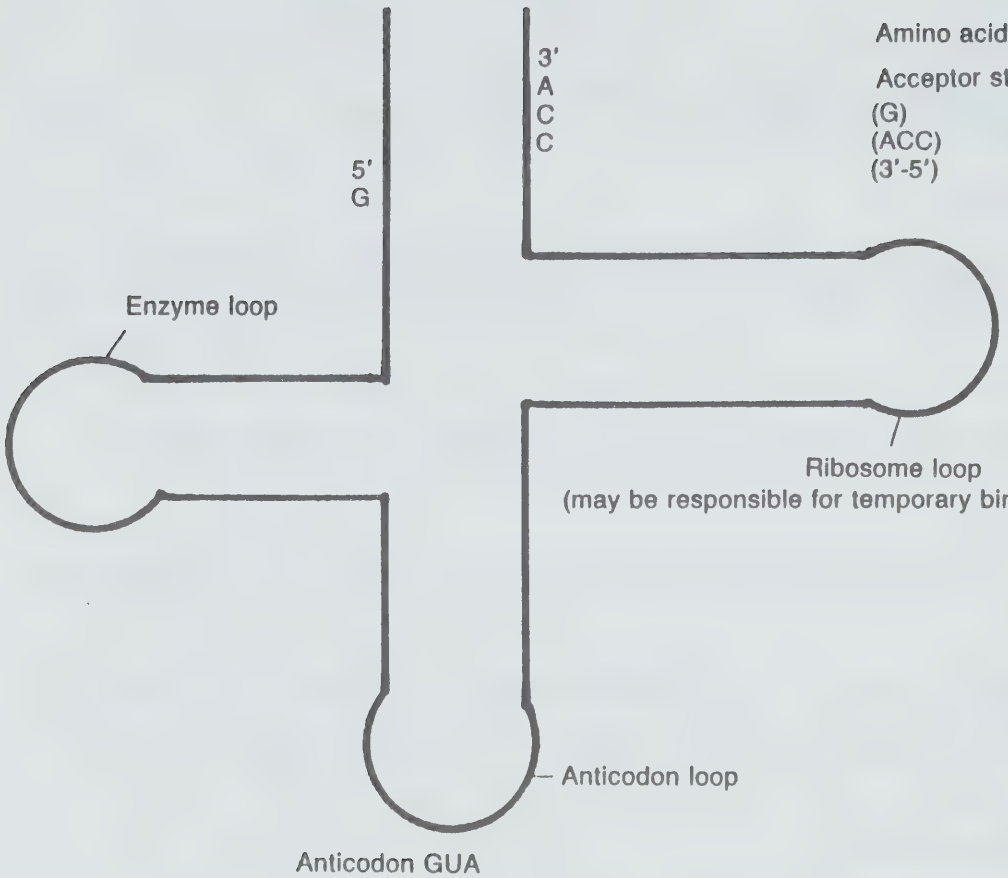
A. -tyrosine tRNA bonds specifically with an activated 2
tyrosine (amino acid) molecule in the cytoplasm

-specific enzyme and ATP necessary for bonding 2

carries the tyrosine to a mRNA molecule in association with a ribosome
on the rough endoplasmic reticulum 2

-the anticodon of the tRNA matches, in a complementary manner a
mRNA codon for tyrosine 2

B.



Amino acid tyrosine (+ATP) 1
Acceptor stem 1
(G) 1
(ACC) 1
(3'-5') 1

Ribosome loop 1
(may be responsible for temporary binding to ribosome) 1

Anticodon loop 1

2

Possible: 18

Maximum: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KgSA.03R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kg
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.6, A.9
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: polypeptide	

Guideline Objective

The students will be expected to, using current theory including information on transcription, translation, mRNA, tRNA, and ribosomes, describe how proteins are synthesized in the cell.

Item Focus

The student will explain the role of DNA in the synthesis of proteins.

Item

Refer to Figure 4K.13.

THE PROCESSING OF INFORMATION IN LIVING CELLS

(A bacterial cell is shown)

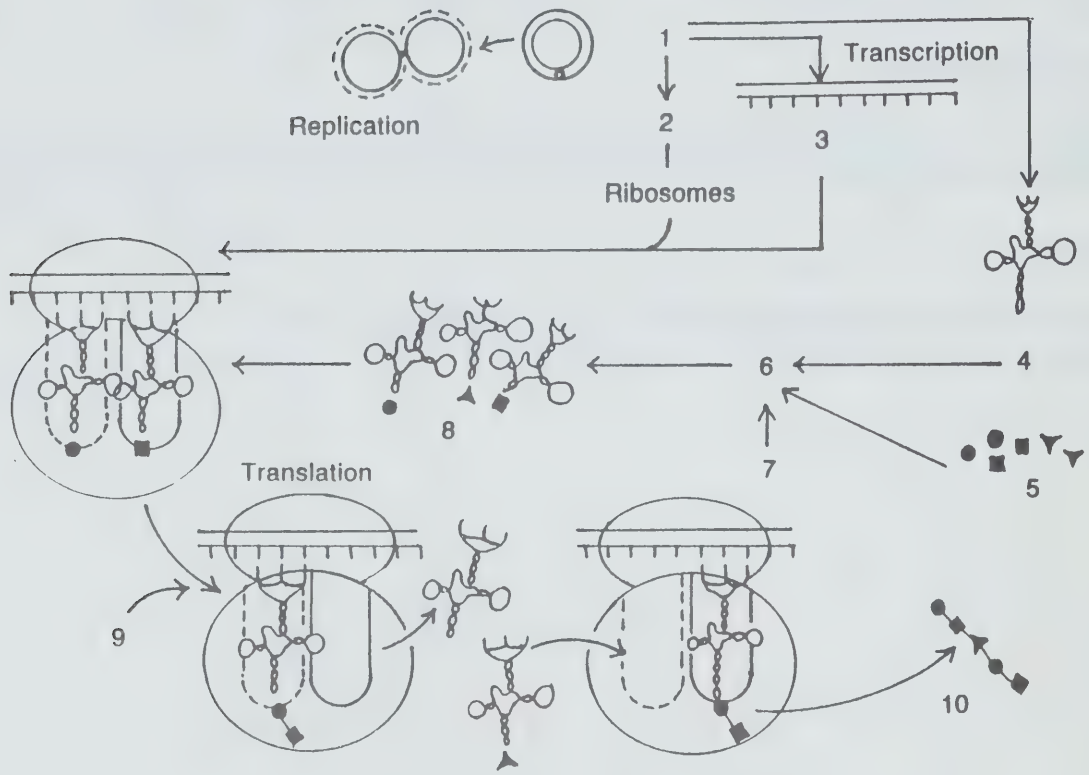


Figure 4K.13 shows, pictorially, the series of reactions central to the processing of information in living cells. Ten numbers appear and each represents the name of a chemical or group of related chemicals. Print the numbers from 1 to 10 on alternate lines of your answer page. Next to each, print the letter, from the list that follows, that corresponds to the number on the diagram. You should not use any letter/chemical name more than once.

Choices of Responses

A.	'A' site	J.	GTP
B.	amino acids	K.	m-RNA
C.	amino acyl t-RNA	L.	operator gene
D.	amino acid activating enzyme	M.	'P' site
E.	ATP	N.	polypeptide
F.	cyclic AMP	O.	repressor protein
G.	DNA	P.	r-RNA
H.	DNA polymerase	Q.	t-RNA
I.	formyl methionine		

Response/Marking Scheme

1. G
2. P
3. K
4. Q
5. B
6. D
7. E
8. C
9. J
10. N

Possible: 10

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KhMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kh
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.3, D.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: inducer operator repressor graphical analysis	

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

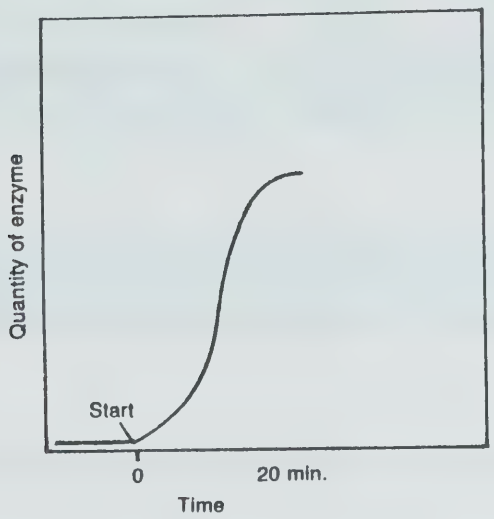
Item Focus

The student should be able to recognize how protein synthesis is controlled.

Item

Refer to Figure 4K.14.

PRODUCTION OF ENZYME BY BACTERIA



In an experiment, a chemical was added to an actively growing culture of bacteria at a time indicated by the arrow on Figure 4K.14. The graph shows the changing quantity of a particular enzyme in the culture medium during the time after the chemical was added. From these data, it appears that the added chemical could best be described as

- ☐ A. the enzyme.
- ☐ B. a gene.
- ☐ C. an inducer.
- ☐ D. an operator.
- ☐ E. a repressor.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KhMC.03
GUIDELINE OBJECTIVE CODE: 41Kh
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: regulatory gene repressor

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to recognize how the synthesis of proteins might be triggered and repressed.

Item

A regulatory gene produces

- ☐ A. a structural protein.
- ☐ B. an enzyme.
- ☐ C. a hormone.
- ☐ D. a repressor protein.
- ☐ E. an antibody.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KhMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kh
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: operator site gene regulation repressor

Guideline Objective

The students will be expected to, with reference to environmental influences and then, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to recognize how the synthesis of proteins might be triggered and repressed.

Item

An operator site on a strand of DNA is

- ☐ A. the segment of DNA to which a repressor protein binds.
- ☐ B. the location of a regulatory gene.
- ☐ C. a sequence of nucleotides coding for a single gene product.
- ☐ D. the part responsible for the synthesis of a repressor protein.
- ☐ E. the segment transcribed into a mRNA molecule.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KhMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kh
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: repressor protein gene regulation

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to recognize how the synthesis of proteins might be triggered and repressed.

Item

A repressor protein

- ☐ A. prevents the action of a regulatory gene.
- ☐ B. prevents any interference with the binding of RNA polymerase to DNA.
- ☐ C. combines with an operator site on a strand of DNA and blocks the gene transcription
- ☐ D. suppresses the action of antibodies.
- ☐ E. reduces the rate of secretion of antibodies.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KhER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kh
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: Jacob/Monod gene regulation gene induction

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

Same as above.

Item

Jacob and Monod discovered that the common bacterium, *Escherichia coli*, could not use milk sugar (lactose) as an energy source when first exposed to it but soon began to use it. They presented a non-evolutionary theory to explain the phenomenon. Name and explain this phenomenon using their theory.

Response/Marking Scheme

The phenomenon illustrated is enzyme induction. Utilizing	1
lactose as an energy source requires the presence of three enzymes not normally present in *E. coli*,	1
a permease, a B-galactoside, and a galactoside acetylase.	3
When lactose is present in the environment, a few molecules diffuse into the cell. Here they combine	1
with a protein in the cytoplasm. It is called	1
repressor or regulator protein and appears in the cell as	1
a result of the transcription/translation of a special regulator gene.	1
The cell also possesses three structural genes	1
which can be transcribed/translated to synthesize the three enzymes that require lactose.	1
Normally, however, they are not.	1
Adjacent to the structural genes is a special region of DNA, the operator gene, thought to be the site of	1
attachment of RNA polymerase.	1
Only if this is exposed can transcription/translation	1
of the structural genes take place. Normally, the operator	1
gene is wrapped in repressor or regulator protein	1
so structural genes are not transcribed. However, lactose combines with regulator protein much more strongly	1
than operator gene combines with regulator protein.	1
Hence, when lactose enters, regulator protein is stripped away from the operator gene.	1
The structural genes are transcribed and the cell machinery produces the needed enzymes.	

Possible: 20

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KhER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kh
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.5., A.9
TOPIC: Protein Synthesis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: operator site repressor protein inducer molecule transcription

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to describe how the synthesis of proteins might be triggered and repressed.

Item

Describe how a repressor protein affects the transcription of a structural gene and how the presence or absence of an inducer molecule in a cell influences the process.

Response/Marking Scheme

The binding of RNA polymerase to a DNA strand is essential for the transcription of a structural gene to mRNA. 1

A short segment of a DNA strand closely associated with a structural gene is called an operator site. 1

A repressor protein, produced by a regulatory gene, is capable of binding to the operator site of the DNA. 2

This operator site overlaps the binding site on the DNA to which the RNA polymerase first becomes attached when initiating the transcription of a structural gene. 1

Thus, when a repressor protein occupies the operator site, it prevents the RNA polymerase from binding to the DNA, and interferes with the transcription of the structural gene. 2

When an inducer molecule is present, it binds to the repressor protein, preventing it from joining with the operator site. 2

This permits the RNA polymerase to bind to the DNA and initiate transcription. 1

If no inducer molecule is present, the repressor protein blocks the transcription of the structural gene. 1

Possible: 11

Maximum: 8

Quality: 2

Total: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KhMA.01
GUIDELINE OBJECTIVE CODE: 41Kh
INSTRUMENT TYPE: MA
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L`
TIME ALLOCATION:

KEYWORDS: regulator gene repressor protein operator site inducer structural gene promoter

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to describe how the synthesis of proteins might be triggered and repressed.

Item

Place the letter which represents the correct definition next to the appropriate number:

____1.	regulatory gene	A.	a set of adjacent structural genes and the operator gene that controls them.
____2.	repressor protein	B.	a molecule that binds to the repressor molecule preventing it from joining on to the operator site of DNA.
____3.	operator site	C.	produces a repressor protein.
____4.	inducer	D.	a gene that turns the structural genes adjacent to it 'on' and 'off'.
____5.	structural gene	E.	the section of DNA to which RNA polymerase first attaches itself to when initiating the transcription of a structural gene.
____6.	promoter	F.	a portion of a gene which is transcribed into RNA but is not translated into a protein.
		G.	a sequence of nucleotides coding for a single gene product, that is transcribed into a mRNA molecule.
		H.	a protein that blocks gene action with an operator site on a DNA molecule.

Response/Marking Scheme

Correct responses:

1 - C, 2 - H, 3 - D, 4 - B, 5 - G, 6 - E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KhSA.01
GUIDELINE OBJECTIVE CODE: 41Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: regulatory gene repressor protein operator site RNA polymerase transcription

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to describe how the synthesis of proteins might be triggered and repressed.

Item

Place the numbers of the following blocks in the correct sequence to summarize the way a cell regulates the expression of its genes.

1. repressor protein
2. prevents transcription of the gene
3. blocks the binding site of RNA polymerase
4. combines with operator
5. regulatory gene site on DNA

Response/Marking Scheme

5, 1, 4, 3, 2

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KhSA.03
GUIDELINE OBJECTIVE CODE: 41Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: regulatory gene promotor site operator site repressor protein

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to describe how the synthesis of proteins might be triggered or repressed.

Item

Refer to Figure 4K.15.

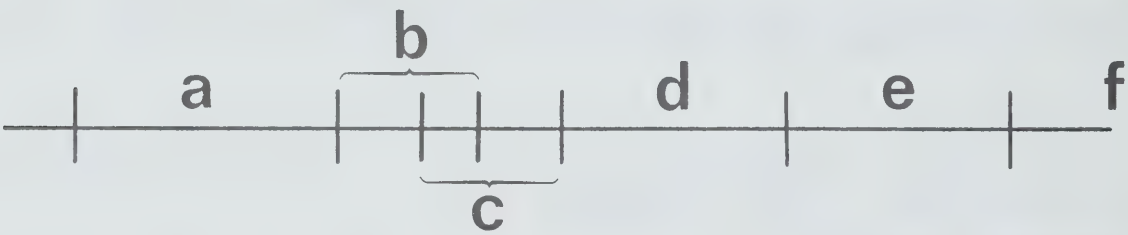


Figure 4K.15 illustrates three structural genes (d, e, and f) on a DNA molecule. Describe the sequence of events which would result in the repression of these genes.

Note: a represents a regulatory gene,
b represents a promotor site, and
c represents an operator site.

Response/Marking Scheme

The regulatory gene a codes for a repressor protein.	1
The repressor protein binds to the operator site c	1
This prevents the RNA polymerase from binding to its promotor site b,	1
preventing the transcription of the structural gene information to mRNA.	1
This, in turn, prevents the synthesis of the proteins.	1
Possible:	5
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KhSA.04
GUIDELINE OBJECTIVE CODE: 41Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.11
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: gene regulation RNA polymerase inducer molecule structural gene repressor protein

Guideline Objective

The students will be expected to, with reference to environmental influences and then, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to describe how the synthesis of proteins might be triggered or repressed.

Item

Refer to Figure 4K.16.

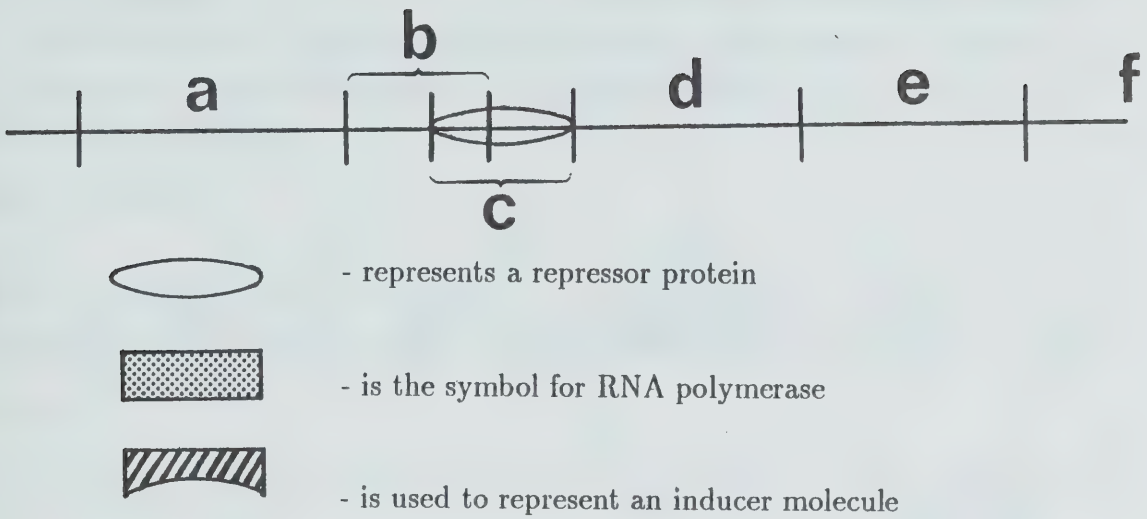


Figure 4K.16 illustrates the repression of the action of the structural genes, d, e, and f.

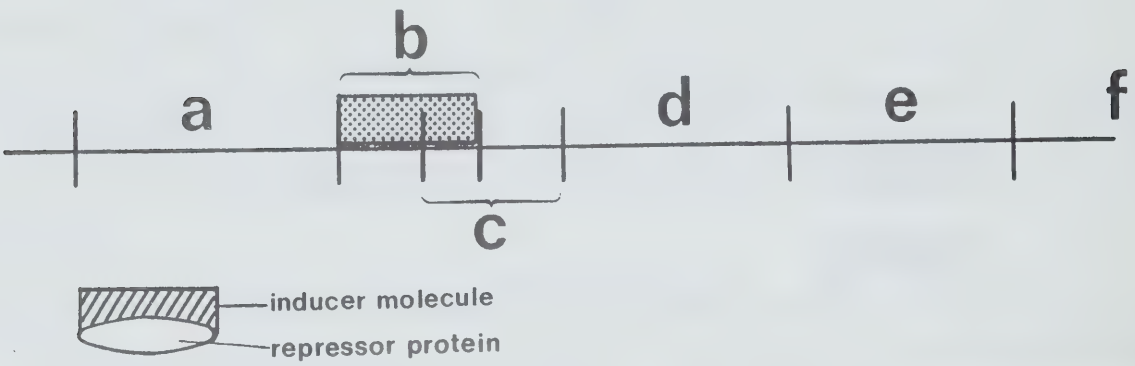
A. Describe how the structural genes are being repressed.

B. Using the symbols provided, draw a diagram to illustrate, and write a description to explain, how the presence of an inducer molecule triggers the synthesis of the proteins by allowing structural genes to function.

Response/Marking Scheme

A. The repressor molecule produced by the regulatory gene a — 1
binds to the operator site c — 1
which blocks the promotor site b — 1
preventing the RNA polymerase from binding to the DNA — 1
preventing the transcription of the genes. — 1

B.



The inducer molecule binds to the repressor protein, preventing it from binding to the operator site of the DNA. — 2
This "frees" the promotor site for the RNA polymerase to bind to the DNA. — 2
RNA polymerase initiates transcription which leads to the synthesis of proteins. — 2

Possible: 14

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Protein Synthesis
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: gene expression

INSTRUMENT CODE: B041KhSA.05
GUIDELINE OBJECTIVE CODE: 41Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The students will be expected to, with reference to environmental influences and, more specifically, regulatory genes, operator sites on DNA, and repressor proteins, describe how the synthesis of proteins might be triggered and repressed and why such control is necessary.

Item Focus

The student should be able to describe how the synthesis of proteins might be regulated and why such control is necessary.

Item

Why is the regulation of gene expression necessary in a cell?

Response/Marking Scheme

The ability to switch genes "on" and "off" is of fundamental ability to the functioning of a cell, and	1
results in a different set of genes being transcribed in each specialized cell.	1
This forms the basis for cell growth and differentiation.	2
It also conserves energy by switching off the synthesis of enzymes when they are not required,	1
enabling a cell to respond to a changing environment.	1
Possible:	6
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Mutation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KiMC.01
GUIDELINE OBJECTIVE CODE: 41Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.4, A.9, A.10, C.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: point mutation

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

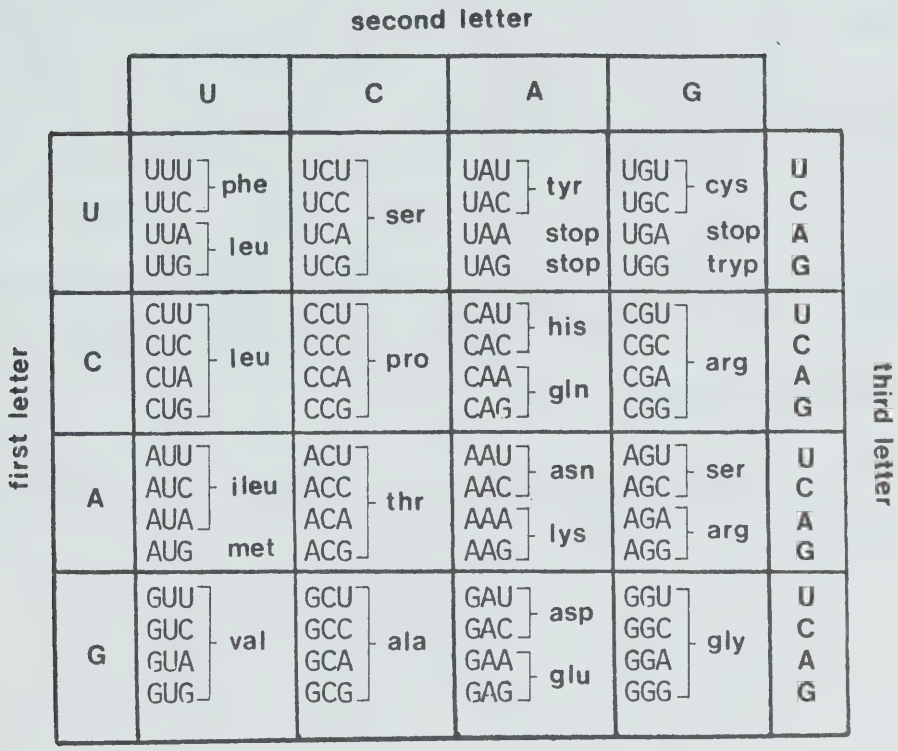
Item Focus

The student should be able to apply knowledge of point mutations.

Item

Refer to Figure 4K.10.

TABLE OF MESSENGER RNA CODONS



Oxytocin is a polypeptide hormone secreted by the posterior pituitary gland. Oxytocin has the amino acid sequence,

GLY-LEU-PRO-CYS-ASN-GLN-ILEU-TYR-CYS.

What is the maximum number of point mutations that could occur without changing oxytocin?

- [ ] A. two
- [ ] B. three
- [ ] C. four
- [ ] D. six
- [ ] E. nine

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Mutation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KiMC.02
GUIDELINE OBJECTIVE CODE: 41Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.4, A.9, A.10, C.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: point mutation

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to apply knowledge of point mutations.

Item

Refer to Figure 4K.10.

TABLE OF MESSENGER RNA CODONS

first letter \ second letter	U	C	A	G	third letter
U	UUU, UUC — phe UUA, UUG — leu	UCU, UCC, UCA, UCG — ser	UAU, UAC — tyr UAA — stop UAG — stop	UGU, UGC — cys UGA — stop UGG — tryp	U C A G
C	CUU, CUC, CUA, CUG — leu	CCU, CCC, CCA, CCG — pro	CAU, CAC — his CAA, CAG — gln	CGU, CGC, CGA, CGG — arg	U C A G
A	AUU, AUC, AUA — ileu AUG — met	ACU, ACC, ACA, ACG — thr	AAU, AAC — asn AAA, AAG — lys	AGU, AGC — ser AGA, AGG — arg	U C A G
G	GUU, GUC, GUA, GUG — val	GCU, GCC, GCA, GCG — ala	GAU, GAC — asp GAA, GAG — glu	GGU, GGC, GGA, GGG — gly	U C A G

Oxytocin and vasopressin are polypeptide hormones secreted by the posterior pituitary gland. Oxytocin has the amino acid sequence,

GLY-LEU-PRO-CYS-ASN-GLN-ILEU-TYR-CYS.

Vasopressin has the amino acid sequence,

GLY-ARG-PRO-CYS-ASN-GLN-PHE-TYR-CYS.

The minimum number of point mutations needed to change the coding of one these polypeptides to that of the other is

- [ ] A. two.
- [ ] B. three.
- [ ] C. four.
- [ ] D. six.
- [ ] E. nine.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Mutation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KiMC.03
GUIDELINE OBJECTIVE CODE: 41Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9, C.2
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: protein synthesis evolution

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

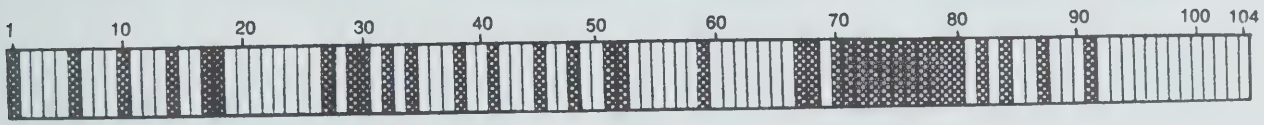
Item Focus

The student should be able to apply knowledge of genetics and protein synthesis to biochemical natural selection.

Item

Refer to Figure 4K.17.

DIAGRAM OF AMINO ACID SEQUENCE IN CYTOCHROME C OXIDASE



An important enzyme, involved in the hydrogen/electron transfer chain of cellular respiration, is cytochrome C oxidase.

Figure 4K.17 represents a molecule of cytochrome C oxidase in which each box represents one amino acid residue. Boxes that are shaded are amino acids that are the same in each of 25 distantly related species for which the biochemical analysis has been performed. These 35 amino acid sites appear to have remained stable. The best hypothesis to account for this is that they are

- A. encoded by immutable codons.
- B. unimportant for proper functioning of the enzyme.
- C. involved in maintaining the shape of the enzyme, or its interactions with the membrane.
- D. part of the active site of the enzyme.
- E. new amino acids that have been added to the enzyme since it first appeared.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Mutation	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: diploid somatic

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to identify the effect of radiation on the process of mitosis.

Item

Radiation causes a gene mutation in a diploid somatic cell undergoing mitosis. What would be the result of this event?

- ☐ A. The entire species will be affected.
- ☐ B. The mutation will become part of the gene pool of successive generations.
- ☐ C. Future generations will not be affected.
- ☐ D. The gametes will be affected.
- ☐ E. In time, all neighbouring cells will be affected.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: Genetics	KLOPFER: A.1, A.2, A.3
TOPIC: Mutation	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: DNA

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to identify the nature of a mutation.

Item

Which of the following best describes mutations?

- ☐ A. They are changes in the DNA.
- ☐ B. They are variations caused by the environment.
- ☐ C. Most of them are harmless.
- ☐ D. They usually involve drastic reorganization of the organism.
- ☐ E. They are restricted to the gametes.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Mutation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KiMC.06
GUIDELINE OBJECTIVE CODE: 41Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to identify the causes of mutation.

Item

Which one of the following would NOT lead to mutation of the DNA in an organism?

- [ ] A. Exposure to ionizing radiation.
- [ ] B. Addition or deletion of nucleotides.
- [ ] C. Substitution of one nucleotide for another.
- [ ] D. Need for change perceived by the organism.
- [ ] E. Certain chemicals in the environment.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Mutation	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: point mutation frame-shift mutation

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

Same as above.

Item

Compare point mutations with frame-shift mutations and discuss the biological importance of each.

Response/Marking Scheme

Mutations are alterations in the base sequence of DNA.	1
In point mutations, the alteration is a result of a single base being changed into another base.	1
Frame-shift mutations occur when a single base is deleted from or inserted into DNA.	2
Both types are significant in creating new base sequences	1
which will result, in many cases, in the production of new or altered proteins.	1
Some of these products may be beneficial to the individual	1
possessing them and be incorporated into the species by natural selection.	
Mutations can also be detrimental to	1
individuals possessing them. A frame-shift mutation can change all the codons following it in the DNA or until	1
the reading frame is re-established (three frame shifts of a type or two of opposite types). Such radical change is likely to result in a greatly altered protein	1
which often will be non-functional. This could be fatal to the organism.	2
Point mutations may be inconsequential due to	1
degeneracy in the genetic code, or lead to	1
a slight change in protein that could improve it.	1
Massive damage to the species is only likely if the codon is changed to a 'stop' codon.	1
	Possible: 16
	Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1(2-13), 3.1(11) 41Ki
UNIT NUMBER: 04	
UNIT NAME: GENETICS	INSTRUMENT TYPE: ER
TOPIC: Science in Society.	KLOPFER: I.1, I.2, I.4, I.5
CURRICULAR EMPHASIS: Science, Technology and Society	DIFFICULTY LEVEL: M
	TIME ALLOCATION:

KEYWORDS: scientific controversies societal issues.

Guideline Objective

The student will be encouraged to develop a commitment to learning about ethical and moral issues that stem from current research.

Item Focus

The student will know that scientific knowledge informs but is not the sole determiner of societal issues.

Item

In the following situation, assume that Dr. A and Dr. B are giving evidence before a group looking into the possible hazard to children exposed to asbestos in primary schools. Both scientists are expert in the field, have reviewed the scientific literature, and have agreed on the validity of the reported observations.

Chair: We now face the question of the extent of the hazard and the consequences to children exposed to asbestos in primary schools. What is your view Dr. A?

Dr. A: In view of the increased hazard which will result from asbestos exposure during childhood, and allowing a long time for the carcinogenic (cancer-causing) effect of asbestos to occur, my opinion is that a policy of no exposure is the only responsible one for us to adopt.

Dr. B: That is surely extreme. These children are going to walk about in cities and be exposed to airborne asbestos from brakelinings of vehicles. Hence, they are unavoidably exposed to certain amounts of asbestos fibres.

Dr. A: That is surely an additional reason for tolerating no further exposure in the schools.

Dr. B: We have agreed that we have no evidence that a few fibres of asbestos in the lung are carcinogenic. It does not seem reasonable to me to insist on a policy of total exclusion from one environment knowing that some exposure is inevitable in another.

Dr. A: In my opinion, unless we take a position of removing exposure to known carcinogens whenever possible, we cannot condone repetitive exposure that is bound to be harmful.

QUESTIONS:

A. Does the problem being discussed lie within the realm of science or outside the realm of science? Explain your answer.

B. What do these scientists agree and disagree about?

C. What considerations may enter into the resulting decision?

(*Science Council of Canada Report #35*, 1982, p. 11).

Response/Marking Scheme

A. The problem has a basis in facts within the realm of science.	1
This is apparent because there is no dispute about scientific concepts.	1
The mechanism for solving the problem lies outside the realm of science.	1
B. The scientists agree about the science involved.	1
The scientists disagree about the threshold of risk from asbestos	1
and about what course of action to follow with regard to asbestos in school buildings.	1
C. Whatever the resulting decision will be, it will not be determined by scientific findings.	1
A number of considerations may enter into the decision,	1
such as cost of replacing asbestos, the possible economic effects of asbestos removal, disruptions to the schools.	1
Possible:	9
Maximum:	6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Mutation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: frameshift mutation codon	

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to identify and describe the effect of a frameshift mutation.

Item

The following sequence of amino acids represents the start of the polypeptide chains in insulin:

glycine - isoleucine -valine - glutamic acid - glutamine -

Assume that the normal sequence of codons on a mRNA molecule coding for the given sequence of amino acids is as follows:

- 5′ - G G U A U U G U C G A G C A A - 3′ - - - - - -

A. What effect would the insertion of a single 'A' (adenosine monophosphate) molecule between the 'G' and the 'U' of the first codon have on the mRNA? Answer by writing out the changed mRNA, together with the sequence of amino acids it would code for. (Use the table of codons provided.)

B. What name is given to the type of genetic change in DNA which results in this change in the mRNA?

TABLE OF MESSENGER RNA CODONS

first letter	second letter: U	second letter: C	second letter: A	second letter: G	third letter
U	UUU, UUC — phe UUA, UUG — leu	UCU, UCC, UCA, UCG — ser	UAU, UAC — tyr UAA — stop UAG — stop	UGU, UGC — cys UGA — stop UGG — tryp	U C A G
C	CUU, CUC, CUA, CUG — leu	CCU, CCC, CCA, CCG — pro	CAU, CAC — his CAA, CAG — gln	CGU, CGC, CGA, CGG — arg	U C A G
A	AUU, AUC, AUA — ileu AUG — met	ACU, ACC, ACA, ACG — thr	AAU, AAC — asn AAA, AAG — lys	AGU, AGC — ser AGA, AGG — arg	U C A G
G	GUU, GUC, GUA, GUG — val	GCU, GCC, GCA, GCG — ala	GAU, GAC — asp GAA, GAG — glu	GGU, GGC, GGA, GGG — gly	U C A G

Response/Marking Scheme

A. mRNA G G A U A U U G U C G A G C A A - - - - 1

(If students make an error in the codon sequence, give credit for correct translation of codons.)

The amino acid sequence would be:

glycine - tyrosine - cysteine - argenine - alanine 5

B. This type of mutation is called a frameshift mutation. 1

Possible: 7

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Mutation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: frameshift mutation codon

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to identify and describe the effect of a frameshift mutation.

Item

The following sequence of amino acids represents the end of one of the polypeptide chains of insulin:

- - - tyrosine - threonine - proline - lysine - alanine -

Assume that the normal sequence of codons on a mRNA molecule coding for the given sequence of amino acids is as follows:

- 5′ - U A C A C A C C C A A G G C C - 3′ -

A. What effect would the deletion of the first base on the codon for threonine have on the mRNA? Answer by writing out the changed mRNA, together with the sequence of amino acids it would code for. (Use the table of codons provided in Figure 4K.10)

B. What is the name given to the genetic change in DNA which causes this change in mRNA?

TABLE OF MESSENGER RNA CODONS

first letter	second letter: U	second letter: C	second letter: A	second letter: G	third letter
U	UUU, UUC: phe UUA, UUG: leu	UCU, UCC, UCA, UCG: ser	UAU, UAC: tyr UAA: stop UAG: stop	UGU, UGC: cys UGA: stop UGG: tryp	U C A G
C	CUU, CUC, CUA, CUG: leu	CCU, CCC, CCA, CCG: pro	CAU, CAC: his CAA, CAG: gln	CGU, CGC, CGA, CGG: arg	U C A G
A	AUU, AUC, AUA: ileu AUG: met	ACU, ACC, ACA, ACG: thr	AAU, AAC: asn AAA, AAG: lys	AGU, AGC: ser AGA, AGG: arg	U C A G
G	GUU, GUC, GUA, GUG: val	GCU, GCC, GCA, GCG: ala	GAU, GAC: asp GAA, GAG: glu	GGU, GGC, GGA, GGG: gly	U C A G

Response/Marking Scheme

A. - 5′ - U A C C A C C C A A G G C C - 3′ - 1

The new amino acid sequence would be as follows:

- tyrosine - histidine - proline - arginine - 4

B. This type of mutation is called a frameshift mutation. 1

Possible: 6

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiSA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Mutation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: point mutation codon

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations and changes in chromosome number.

Item Focus

The student should be able to identify and name a point mutation.

Item

The following nitrogenous base sequence represents a part of a mRNA molecule:

- 5′ - G A C C U U U G G A C U - 3′ -

A. What single change in the mRNA would be necessary to produce the following sequence of amino acids?

- aspartic acid - proline - tryptophan - isoleucine -

B. Write down the sequence of nitrogenous bases on the mRNA molecule which codes for the amino acids mentioned above.

C. What name is given to the genetic change in DNA which causes this change in the mRNA?

TABLE OF MESSENGER RNA CODONS

first letter	second letter: U	second letter: C	second letter: A	second letter: G	third letter
U	UUU phe UUC phe UUA leu UUG leu	UCU ser UCC ser UCA ser UCG ser	UAU tyr UAC tyr UAA stop UAG stop	UGU cys UGC cys UGA stop UGG tryp	U C A G
C	CUU leu CUC leu CUA leu CUG leu	CCU pro CCC pro CCA pro CCG pro	CAU his CAC his CAA gln CAG gln	CGU arg CGC arg CGA arg CGG arg	U C A G
A	AUU ileu AUC ileu AUA ileu AUG met	ACU thr ACC thr ACA thr ACG thr	AAU asn AAC asn AAA lys AAG lys	AGU ser AGC ser AGA arg AGG arg	U C A G
G	GUU val GUC val GUA val GUG val	GCU ala GCC ala GCA ala GCG ala	GAU asp GAC asp GAA glu GAG glu	GGU gly GGC gly GGA gly GGG gly	U C A G

Response/Marking Scheme

A. The central nitrogenous base in the codon for leucine (CUU), that is, uracil, would have to be replaced by the nitrogen base cytosine, which would give the codon for proline (CCU). 4

B. mRNA: - 5′ - G A C C C U U G G A U C - 3′ - 1

C. This type of mutation is called a point mutation. 1

Possible: 6

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KiSA.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Ki
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.9
TOPIC: Mutation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: point mutation codon	

Guideline Objective

The students will be expected to describe how mutagens, such as radiation and chemicals, can change the genetic material in cells by causing mutations, for example, point and frameshift mutations changes in chromosome number.

Item Focus

The student should be able to describe point mutations.

Item

A molecule of haemoglobin consists of four polypeptide chains bonded together, two identical alpha chains and two identical beta chains.
The sequence of amino acids at the start of the beta chain is as follows:

valine	-	histidine	-	leucine	-	threonine	-	proline	-
1		2		3		4		5	

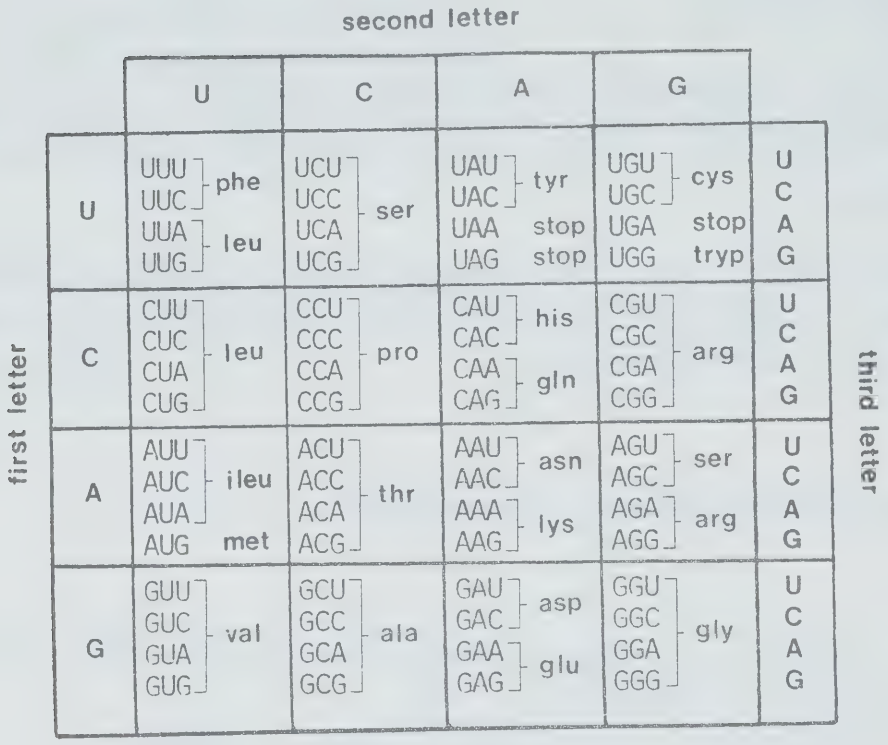
glutamic acid	-	glutamic acid	-	lysine
6		7		8

A mutant allele results form the formation of an abnormal form of haemoglobin which results in a deformity of the red blood cells called 'sickling'. The effects of this abnormality can vary from mild anaemia to death. The difference between the normal and the abnormal haemoglobin is that the glutamic acid in position 6 of the beta chain is replaced by valine.

A. Using the table of codons provided, describe and illustrate the possible point mutations involving one nucleotide which could result in sickling.

B. Draw the normal and mutated DNA triplets, together with the codons for glutamic acid and valine involved.

TABLE OF MESSENGER RNA CODONS



Response/Marking Scheme

A. The only codons for glutamic acid which can be changed into codons for valine by substituting one nucleotide are:

i) glutamic acid codon valine codon

5′ - G A A - 3′ ⟶ 5′ - G U A - 3′ 2

ii) 5′ - G A G - 3′ ⟶ 5′ - G U G - 3′ 2

In both cases, the central adenine molecule of the glutamic acid codon is replaced by uracil to form a valine codon. 1

B. The normal and the mutated DNA triplets would be:

glutamic acid codon		normal DNA triplet	mutated DNA triplet		valine codon	
5′		3′	3′		5′	
G		C	C		G	
A	⟶	T	A	⟶	U	2
G		C	C		G	
3′		5′	5′		3′	
5′		3′	3′		5′	
G		C	C		G	
A	⟶	T	A	⟶	U	2
A		T	T		A	
3′		5′	5′		3′	

In both cases, the point mutations involve the replacement of thymine in the DNA triplet with adenine. 1

Possible: 10

Maximum: 10

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KjER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kj
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.7, A.10, F.1
TOPIC: Research and Technology	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: restriction enzyme

Guideline Objective

Students will be expected to describe three or more techniques of genetic research that make genetic engineering possible, e.g., the use of restriction enzymes to analyse genes, the use of reverse transcriptase to synthesize DNA from RNA, the synthesis and cloning of recombinant DNA.

Item Focus

The student should be able to calculate the probability of a particular outcome of the action of a restriction enzyme.

Item

A genetic engineer works with a restriction enzyme that severs DNA at any site where the sequence of bases is $^{5'}$-A-T-A-C-$^{3'}$. He exposes a gene fragment of 1100 base pairs in length to the enzyme. Assume that there is an equal probability of the occurrence of each of the base pairs in the fragment. After the enzyme has done its work, how many pieces of the gene fragment should he have? Explain your reasoning.

Response/Marking Scheme

Five pieces.	1
The probability of any particular base occurring at a point in the DNA sequence is 1 in 4 = 0.25.	1
Thus the probability of the sequence -A-T-A-C- occurring at a point is $0.25 \times 0.25 \times 0.25 \times 0.25 = 0.000015 = 1.5 \times 10^{-5}$	1
Thus, on average, an A-T-A-C-sequence will occur every 256 base pairs.	1
A gene fragment of 1100 base pairs should contain $\frac{1100}{256}$ or about 4 such points.	1
Thus 4 cuts would make 5 pieces of gene fragment.	

Possible: 5

Maximum: 5

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Research and Technology

CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KjER.02
GUIDELINE OBJECTIVE CODE: 41Kj
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.7
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: genetic engineering

Guideline Objective

Students will be expected to describe three or more techniques of genetic research that make genetic engineering possible, e.g., the use of restriction enzymes to analyse genes, the use of reverse transcriptase to synthesize DNA from RNA, the synthesis and cloning of recombinant DNA.

Item Focus

Same as above.

Item

Human growth hormone, once collected with difficulty from the pituitary glands of cadavers, is now produced by bacteria. Explain briefly the possible role in this development of each of the following:

A. plasmids,

B. DNA ligase,

C. restriction enzymes,

D. reverse transcriptase.

Response/Marking Scheme

A. Plasmids are used to introduce the human gene for GH	1
into bacteria, in a form which the bacteria can	1
transcribe and translate.	1
B. DNA ligase is an enzyme used to incorporate the gene for GH	1
into a plasmid.	1
C. Restriction enzymes are used to break up the DNA of a	1
human cell in an attempt to locate the segment that codes for GH.	1
D. If cells making GH are very specialized,	1
reverse transcriptase can be used as a catalyst	1
with the m-RNA of the cell	1
to direct the synthesis of GH DNA.	1
Possible:	11
Maximum:	8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KjER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kj
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Genetic Engineering	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: restriction enzymes reverse transcriptase recombinant DNA

Guideline Objective

Students will be expected to describe three or more techniques of genetic research that make genetic engineering possible, e.g., the use of restriction enzymes to analyse genes, the use of reverse transcriptase to synthesize DNA from RNA, the synthesis and cloning of recombinant DNA.

Item Focus

Same as the above.

Item

Select two of the following topics and for each, describe, with the aid of diagrams where appropriate, how these genetic research techniques make possible genetic engineering.

a. The Use of Restriction Enzymes

b. The Use of Reverse Transcriptase

c. The Synthesis and Cloning of Recombinant DNA

Response/Marking Scheme

Accept any 2 @ 3 for description and 2 for diagram: 10

a) Restriction enzyme cuts DNA strands
by hydrolyzing nucleic acids
at specific sites,
making identical complementary ends.
This made possible the genetic engineering technique
of combining DNA from different species.

b) Reverse transcriptase is an enzyme
found in some viruses
that can synthesize DNA
from an RNA template,
contrary to the central dogma.
It was a useful tool in producing a gene from
its mRNA, to isolate the gene for human insulin.

c) Synthesis and cloning of recombinant DNA is achieved
by inserting a selected gene into a plasmid,
and inserting the plasmid into a bacterium.
The bacteria are then multiplied in tissue culture
until a large quantity of the selected gene has
been expressed as a large quantity of protein.

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Engineering
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KjER.04
GUIDELINE OBJECTIVE CODE: 41Kj
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS: restriction enzymes recombinant DNA

Guideline Objective

Students will be expected to describe three or more techniques of genetic research that make genetic engineering possible, e.g., the use of restriction enzymes to analyze genes, the use of reverse transcriptase to synthesize DNA from RNA, the synthesis and cloning of recombinant DNA.

Item Focus

Same as the above.

Item

The use of restriction enzymes is an important genetic research technique employed in the field of genetic engineering. By including in your answer the terms, bacteriophage, ligases, plasmids, restriction enzymes, and bacteria, describe how recombinant DNA technology is used to create new gene combinations. Include diagrams where appropriate.

Response/Marking Scheme

Bacteriophages inject their DNA into bacteria.	1
Phage DNA is replicated and expressed in bacteria.	1
reproducing new bacteriophages.	1
Plasmids are circular rings of bacterial DNA.	1
Plasmids are transferred from one bacterium to another.	1
Restriction enzymes cut DNA at specific points,	1
creating identical ends that can rejoin.	1
Ligases are enzymes that repair damaged DNA,	1
joining up the cut ends.	1
In recombinant DNA technology, plasmids are cut	1
and foreign DNA (genes) are inserted.	1
The new gene combination can be multiplied in bacterial culture.	1
In this way, genes have been isolated and the sequence of their component bases identified.	1
Also, hormones such as human insulin have been synthesized in mass production.	1
Appropriate diagrams.	3
Possible:	17
Maximum:	12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KkER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1,(3.1-11) 41Kk
UNIT NUMBER: 04	
UNIT NAME: GENETICS	INSTRUMENT TYPE: ER
TOPIC: Genetic Research	KLOPFER: A.1, A.2, A.3, I.2, I.5
CURRICULAR EMPHASIS: Science, Technology and Society	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: prenatal diagnosis genetic disorders

Guideline Objective

Students will be encouraged to develop a commitment to learning about ethical and moral issues that stem from current research and technologies in genetics.

Item Focus

The student will demonstrate an understanding that prenatal information about the status of the fetus does not make clear the decision as to what course of action the parents should follow.

Item

Prenatal diagnosis has allowed for the early recognition of some types of genetic diseases present in human fetuses. It seems likely that the ability will improve to diagnose genetic disorders prenatally and to predict reasonably which fetuses may develop genetic disorders in the future. In this way, potential parents have the opportunity to become better informed. However, this does not make any easier the decision as to what course of action to take.

A. State two advantages for potential parents of being better informed through prenatal tests.

B. State two disadvantages for potential parents of being informed through prenatal tests.

C. On what basis will parents probably make decisions as to what to do if prenatal tests indicate a high probability of genetic disorders in the fetus?

Response/Marking Scheme

A. Accept any two answers at 2 marks each. 4

If the test results indicate the fetus is normal, the parents' anxiety levels will drop. This will possibly have a good effect on the developing fetus. The parents can make an informed choice if the test results indicate genetic disorders in the fetus. In the future, it is possible that more genetic disorders can be treated in utero if medical conditions can be effectively diagnosed. If genetic disorders are present in the fetus, the parents are better prepared for the difficulties which will be encountered in raising the child.

B. Accept any two answers at 2 marks each. 4

The anxiety levels of the parents may be greatly increased if it is ascertained that the fetus does have genetic problems, because the parents must make a choice as to what to do. If information becomes public, the child and eventually the adult could encounter difficulties in obtaining such things as life insurance. The parents are faced with the spectre of suffering guilt for whatever decision they make.

C. The knowledge gained through prenatal diagnosis only informs parents, it does not offer advice on what decision to make. Probably the decision will be primarily based on moral, ethical, or economic grounds, or a combination of all three. 2

Possible: 10

Maximum: 7

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Research and Technology

CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B041KkSA.01
GUIDELINE OBJECTIVE CODE: 41Kk
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.7, A.10, D.4, F.1, I.4
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: genetic resistance

Guideline Objective

The students will be expected to briefly describe the following phenomena and discuss the social issues, including the benefits and risks of one or more of them:

- gene modification and insertion in prokaryotes so that they can be used to produce useful biochemicals;
- the production of desirable hybrids of domestic plants and animals through genetic engineering;
- the possible modification and selection of genes in humans;
- the application of DNA technology in the diagnosis of prenatal and postnatal genetic diseases.

Item Focus

The student should be able to explain the process of breeding for genetic resistance to disease.

Item

In plants, resistance to disease is usually due to a single gene. Would this be an asset or a hindrance to plant breeders trying to transfer resistance to a crop? Explain your reasoning.

Response/Marking Scheme

This is an asset,	1
because this makes the trait fairly easy to select for	1
or to transfer from strain to strain.	1
Although the breeder must remain aware of other traits, resistance can easily be monitored and bred for.	1
Possible:	3
Maximum:	3

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.10
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Down's syndrome Klinefelter's syndrome

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to describe the chromosomal abnormalities which cause Down's syndrome and Klinefelter's syndrome.

Item

How many chromosomes would occur in each somatic cell of a person who has combined Down's/Klinefelter's syndromes?

- ☐ A. 23
- ☐ B. 45
- ☐ C. 46
- ☐ D. 47
- ☐ E. 48

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: hemophilia sex-linked

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to recognize the pattern of inheritance of haemophilia.

Item

Haemophilia is expressed in the phenotype by

- ☐ A. females only.
- ☐ B. males only.
- ☐ C. females, usually.
- ☐ D. females, rarely.
- ☐ E. males and females equally.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Down's Syndrome chromosome aberrations

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to identify the causes of genetic diseases such as Down's Syndrome.

Item

Down's Syndrome

- [ ] A. occurs only in females.
- [ ] B. is a point mutation.
- [ ] C. is a result of an extra chromosome.
- [ ] D. is caused by a missing chromosome.
- [ ] E. is a homozygous, recessive trait.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3.
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Down's syndrome translocation

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to identify a process that leads to a disease of chromosome abnormality.

Item

In some cases of Down's syndrome, a portion of a third chromosome 21 is found to be attached to a different chromosome. This abnormality is an example of

- ☐ A. chromosomal inversion.
- ☐ B. non-disjunction.
- ☐ C. point mutation.
- ☐ D. translocation.
- ☐ E. deletion.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Diseases
CURRICULAR EMPHASIS: Practical Application

INSTRUMENT CODE: B041KlEE.01R
GUIDELINE OBJECTIVE CODE: 41Kl 42ci
INSTRUMENT TYPE: EE
KLOPFER: A.1, A.2, A.7, I.5
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: chromosomes metabolic errors

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to describe possible solutions and/or treatments for genetic diseases.

Item

Most genetic diseases fall into one of two categories, based on the cause of the malfunction. Some, like Down's, Turner's, and Klinefelter's syndromes are caused by errors in meiosis which result in an abnormal number of chromosomes. A second group, such as Tay-Sachs disease and haemophilia, are the result of gene mutations which prevent the synthesis of essential proteins, causing severe metabolic problems. Summarize possible medical procedures for the second group of diseases, including the part genetic counselling may play.

Response/Marking Scheme

Early detection of 'metabolic' diseases is invaluable 1
since it is often the accumulation of lethal substances in essential organs. 1
Early, pre-natal detection of fetal chromosomal abnormalities, together with therapeutic abortions, give parents the choice of avoiding birth of a child who may die in infancy. 1
Amniocentesis, which involves withdrawing amniotic fluid from the amnion (a fluid filled sac inside which the fetus is developing) enables early detection of genetic abnormalities. 1
The amniotic fluid contains fetal cells which can be tissue cultured and subjected to chromosomal examination (karyotyping) and to biochemical analysis. 2
Over 100 metabolic errors are detectable by amniocentesis. Sometimes all that is needed to avoid the symptoms of a genetic disease is an adjustment of diet, 1
usually to exclude the substance which can no longer be broken down due to an enzyme deficiency. 1
Many genetic diseases are fatal only when the genotype for the harmful trait is homozygous recessive, 1
and it is helpful to be able to detect heterozygous carriers. 1
It is possible to detect reduced enzyme levels in the heterozygous carriers of many genetic diseases, such as Tay-Sachs and P.K.U. 1
thus alerting individuals to potential problems. 1
Some success has been achieved in attempting to supply the missing enzyme to the cells requiring it. 1
The required enzyme is packaged inside membrane vesicles and injected into patients' blood. Vesicles fuse with membranes of target cells, introducing the enzyme into the cytoplasm. 1
The enzyme then breaks down accumulated harmful molecules. 1
The fact that molecular biologists can sequence genes in a matter of weeks and clone them as well, 1
the successful transplantation of genes across the widest possible range of morphological and evolutionary differences (human-bacteria) 1
opens up the possibility of synthesizing 'healthy' genes and introducing them into patients to replace deficient genes. 1
Not all researchers believe this to be feasible. 1
Some workers have successfully assembled an artificial chromosome, which had limited functional success. 1

Pre-natal diagnosis, therapeutic abortions and genetic screening have highlighted the function of genetic counsellors, 1

and medical specialists, who, by studying the family pedigree can provide parents with potential probabilities as to the chances of having a child with a genetic disorder. 1

Counsellors can also assist parents to adjust to the birth of such a child. 1

They can give advice regarding pre-natal diagnosis and possible therapeutic abortion. 1

Genetic counsellors are not prescriptive, their role is supportive and informative, the final decision is the parents'. 1

Possible: 26

Maximum: 20

Quality: 5

Total: 25

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundationss	TIME ALLOCATION:

KEYWORDS: haemophilia sex chromosomes sex determination

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to predict the probability of transmitting a genetic disease.

Item

As a result of a mutation, the allele for haemophilia is believed to have arisen in Queen Victoria. Leopold, Duke of Albany, one of Victoria's children, was a haemophiliac. Leopold had two children, one male and one female.

Explaining your reasoning in each case, predict

A. the probability that Leopold's brother, Edward, was also a haemophiliac.

B. the probability that Leopold's son was a haemophiliac.

C. the probability that Leopold's daughter was a carrier of haemophilia.

Response/Marking Scheme

A. 50% or one-half. 1

Edward received a copy of one X-chromosome of the two that Queen Victoria carried. 1

(Fortunately, he received the normal one.)

B. Zero. 1

Leopold cannot pass a copy of his defective X-chromosome to his son: he must provide the Y-chromosome. 1

C. 100% or 1. 1

Since Leopold's X-chromosome is defective, he must pass a copy of it to his daughter. 1

Possible: 6

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlMA.01R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: MA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.6
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Down's Syndrome Klinefelter's Syndrome Turner's Syndrome

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to identify symptoms and characteristics of human genetic diseases such as Down's Syndrome, Klinefelter's Syndrome, and Turner's Syndrome.

Item

You are given the names and characteristics of three genetic diseases of humans as follows:

1. Klinefelter's Syndrome, Down's Syndrome, and Turner's Syndrome
2. $2n + 1 = 47$, $2n - 1 = 45$, $2n = 46$
3. male, female, both male and female
4. XO, XXY, XYY, OY, an extra autosome

Study the information given above and arrange the appropriate response under the correct heading in the following table: (Note: some responses may be used more than once.)

1. Name of syndrome	2. Number of chromosomes	3. Sex of affected person	4. Nature of chromosome abnormality
Klinefelter's			
Down's			
Turner's			

Response/Marking Scheme

1. Name of syndrome	2. Number of chromosomes	3. Sex of affected person	4. Nature of chromosome abnormality
Klinefelter's	2n + 1 = 47	male	XXY 3
Down's	2n + 1 = 47	either male or female	extra autosome number 21 3
Turner's	2n - 1 = 45	female	XO 3

Possible: 9

Maximum: 9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlMA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: MA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.6
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Down's syndrome haemophilia Klinefelter's syndrome Turner's syndrome Huntingtons chorea muscular dystrophy Tay-Sachs disease cystic fibrosis

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, such as Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to describe the effects of 2 or more genetic diseases.

Item

In the blank to the left of each, match the letter of the genetic disorder with the number of the paragraph which describes its symptoms.

A. ____ Tay-Sachs disease
B. ____ Down's syndrome
C. ____ Huntington's chorea
D. ____ Klinefelter's syndrome
E. ____ Muscular dystrophy
F. ____ Turner's syndrome
G. ____ Cystic fibrosis

1. Short statured females with webbed neck, low set ears, broad chest, underdeveloped breasts, small uterus and abnormal ovary development.

2. Slow, progressive degeneration of the muscles. Most often occurs in males. Some muscles enlarged due to fat accumulation, others wither.

3. Death in infancy due to abnormal metabolism of lipids, which accumulate in the brain.

4. Thickened, viscous secretions of the mucosal linings of the lungs, intestine and pancreas which cause obstruction and blockage of these organs. Accompanied by large salt loss.

5. Subnormal intelligence, folding of eyelids, short stature, stubby fingers, swollen tongue.

6. Fatal degeneration of the nervous system. Symptoms may develop as early as childhood or as late as 60 years of age. Mean age of onset is 40 years.

7. Lack of a blood protein which is essential for the clotting of the blood.

8. Sterile males, with long legs and small testes. Sparse body hair, female like breasts.

Response/Marking Scheme

A. 3
B. 5
C. 6
D. 8
E. 2
F. 1
G. 4

Possible: 7

Maximum: 7

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.10
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Turner's syndrome Klinefelter's syndrome

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

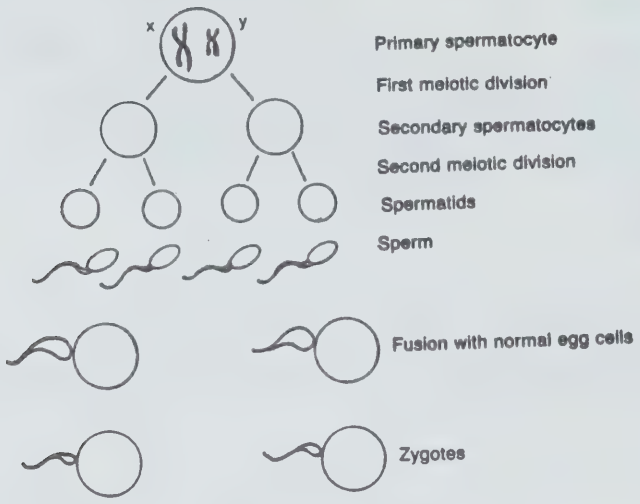
Item Focus

The student should be able to describe the cause of Turner's syndrome and Klinefelter's syndrome.

Item

Refer to Figure 4K.18.

SPERMATOGENESIS AND FERTILIZATION

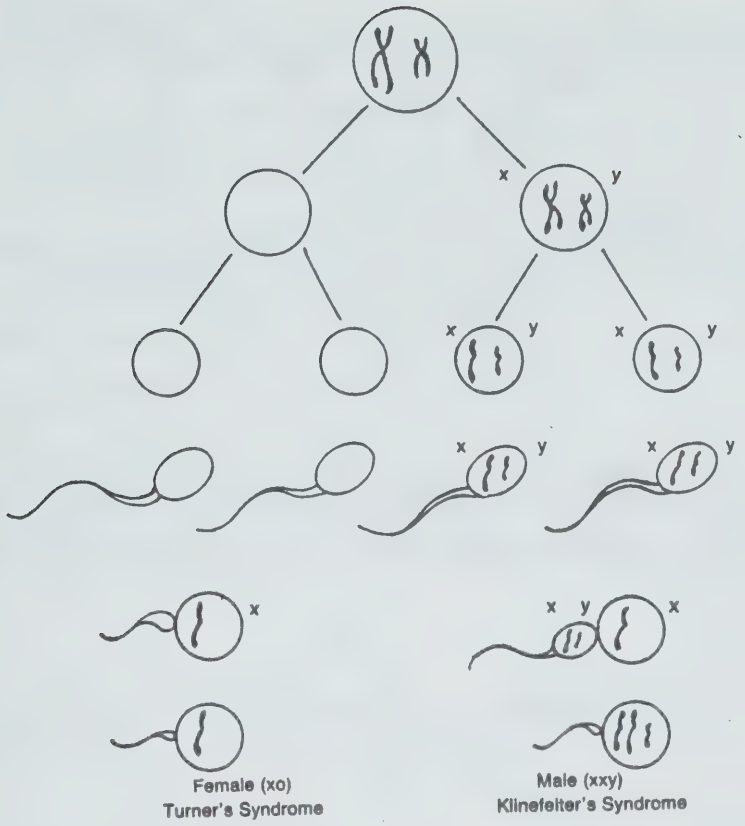


Although the human X and Y chromosomes are different in structure (non-homologous) they synapse during prophase I of meiosis, just as the members of the homologous pairs do. In the diagram of spermatogenesis, (Figure 4K.18), the sex chromosomes do not separate during anaphase I (non-disjunction). If these abnormal sperm succeed in fertilizing normal eggs, the resulting embryos will have abnormal genetic conditions.

A. Draw the symbolic X and Y chromosomes in the secondary spermatocytes, spermatids and sperm shown in Figure 4K.18.

B. Draw diagrams showing the fusion of each different type of sperm formed with a normal egg.
   Include the X and Y chromosomes in these diagrams.
   Indicate the sex and the genetic condition of the eventual embryos.

Response/Marking Scheme



2

2

2

2

2

2

Possible: 10

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Diseases
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KlSA.02
GUIDELINE OBJECTIVE CODE: 41Kl
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Down's syndrome non-disjunction trisomy translocation duplication

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to describe the cause of Down's syndrome.

Item

Give 3 possible chromosome abnormalities that would result in Down's syndrome.

Response/Marking Scheme

Several chromosomal abnormalities can cause the characteristics of Down's syndrome. The most common is a non-disjunction of	1
chromosome pair 21 which leads to trisomy (2n+1)	2
Alteration of normal chromosome structure by translocation is another cause of Down's syndrome.	1
When a portion of one chromosome becomes physically associated with another, usually non-homologous chromosome.	1
Duplication of only a sector of chromosome 21 can produce the syndrome.	1
Possible:	6
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Diseases
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KlSA.03
GUIDELINE OBJECTIVE CODE: 41Kl
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Down's syndrome graphical analysis

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

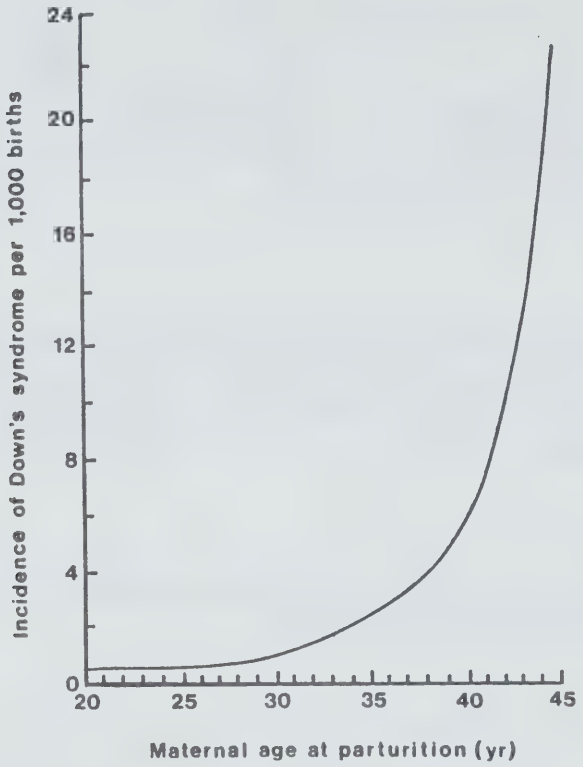
Item Focus

The student should be able to describe and explain the relationship between the age of a mother when she has her child and Down's syndrome.

Item

Refer to Figure 4K.19.

RELATIONSHIP BETWEEN DOWN'S SYNDROME AND MATERNAL AGE



Graph adapted from
Crawley, Philip H. et al. in
Nature, 280: 417, 1979.

A. From the graph, state the relationship between the incidence of Down's syndrome and the mother's age at the time she gives birth.

B. Discuss the probability of having a Down's syndrome child at any age. At what age does the probability increase considerably? What is the probability of having a normal child at age 45?

C. Give a possible explanation for the relationship shown on the graph.

Response/Marking Scheme

A. The older the mother is when she gives birth, the greater the risk of producing a Down's child. 1

B. At any age, the probability of having a Down's child is very small: 1

1 chance in 1000 at age 20; 2 in 1000 at age 35, 6 in 1000 at age 40, and 22 in 1000 at age 45. 1

Thus even at age 45, when the probability has increased considerably, there is a 78% chance of having a normal child. 1

C. Evidence suggests non-disjunction occurs more frequently in older oocyte mother cells. 1

Physiological difficulties appear to be more prevalent in eggs of older women. 1

Large numbers of oocytes (approx 3,400,000) develop in the female fetus 1

which go through 1st stages of meiosis during 4th-7th month of fetal life. 1

The eggs remain in the ovary in diplotene stage until stimulated by FSH and LH. 1

One oocyte is released per menstrual cycle from puberty until menopause at 50-55 years of age. 1

Possible: 10

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KlSA.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Kl
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.4
TOPIC: Genetic Diseases	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: chromosomal aberration Down's Syndrome

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, such as Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

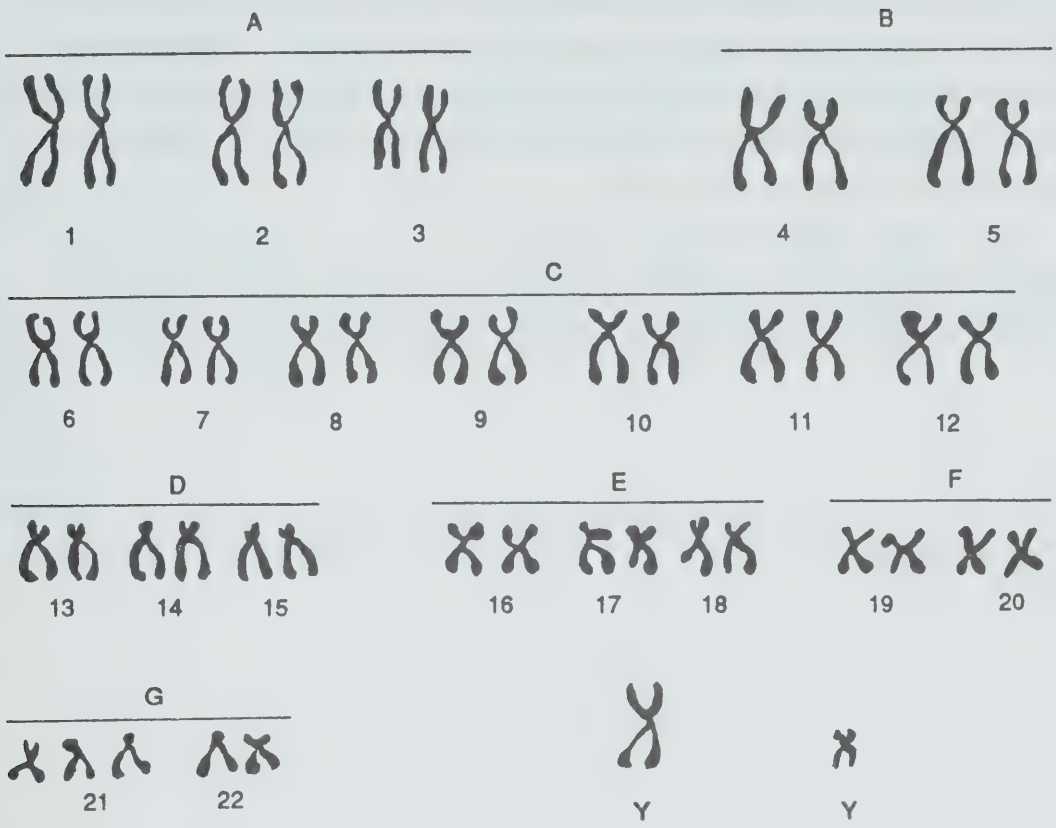
Item Focus

The student should be able to identify the chromosomal aberration, Down's Syndrome.

Item

Refer to Figure 4K.20.

A HUMAN KARYOTYPE



A. Identify the chromosomal aberration shown in the karyotype shown in Figure 4K.20.

B. What are three symptoms resulting from this chromosomal aberration?

C. Suggest one way by which this genetic defect of the cell could arise.

Response/Marking Scheme

a. The chromosomal aberration shown in Figure 4K.20 is Down's Syndrome or Trisomy 21. 1

b. Any three of the following symptoms: short stature, a round face with epicanthal folds, broad fingers and toes, a large protruding tongue, unusual finger and palm prints (including a single transverse palmar crease called a simian crease), mental retardation, and multiple physiological malfunctions of the heart, respiratory system, or kidneys. 3

c. One way in which this condition might arise would be as the result of the nondisjunction of the chromosome pairs during the first meiotic division or the non-disjunction of the chromatids during the second meiotic division. 2

Possible: 6

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Diseases
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B041KlSA.05R
GUIDELINE OBJECTIVE CODE: 41Kl
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Down's Syndrome Klinefelter's Syndrome Turner's Syndrome

Guideline Objective

Students will be expected to describe the cause of, effects, possible solutions to and/or treatments for two or more human genetic diseases, e.g. Down's syndrome, haemophilia, Klinefelter's syndrome, Turner's syndrome, Huntington's chorea, muscular dystrophy, Tay-Sachs disease and cystic fibrosis.

Item Focus

The student should be able to identify symptoms and characteristics of human genetic diseases such as Down's Syndrome, Klinefelter's Syndrome, and Turner's Syndrome.

Item

For each of Klinefelter's Syndrome, Down's Syndrome, and Turner's Syndrome, describe

A. the number of chromosomes in each somatic cell.

B. the sex of the affected person.

C. the nature of the chromosome abnormality (e.g., whether there is an XXY, or XYY, etc., combination of chromosomes present).

Place your answers in the spaces provided in the table below.

Name of syndrome	A. Number of chromosomes	B. Sex of affected person	C. Nature of chromosome abnormality
Klinefelter's			
Down's			
Turner's			

Response/Marking Scheme

Name of syndrome	A. Number of chromosomes	B. Sex of affected person	C. Nature of chromosome abnormality
Klinefelter's	2n + 1 = 47	male	XXY 3
Down's	2n + 1 = 47	either male or female	extra autosome number 21 3
Turner's	2n - 1 = 45	female	XO 3

Possible: 9

Maximum: 9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmMC.01
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Meselson Stahl DNA centrifugation isotope

Guideline Objective

The student will be expected to describe how the experiments of various biologists, for example, Mendel, Feulgen, Mullen, Grittith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

Item Focus

The student should be able to interpret and explain the experimental data of M. Meselson and F. Stahl which has contributed to our understanding of genetics.

Item

Refer to Figure 4K.21.

THE MESELSON AND STAHL EXPERIMENT

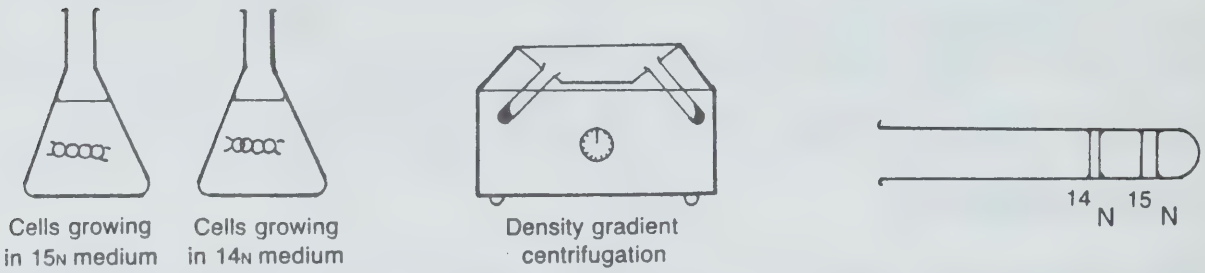


Figure 4K.21 illustrates the apparatus and technique used by M. Meselson, anmd F. Stahl in 1955 to separate DNA molecules of two different densities. The technique, which made use of isotopes of nitrogen, is called density gradient centrifugation. (^{14}N is the normal isotope of nitrogen).

*E. coli*cells were grown in a medium of ^{15}N isotopes because

- A. they grow better in ^{15}N.
- B. their DNA molecules would be as dense as the normal.
- C. their DNA molecules would be less dense than normal.
- D. ^{15}N is radioactive.
- E. their DNA molecules would be more dense than normal.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmMC.02
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Meselson Stahl DNA centrifugation isotope

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

Item Focus

The student should be able to interpret and explain the experimental data of M. Meselson and F. Stahl which has contributed to our understanding of genetics.

Item

Refer to Figure 4K.22.

THE MESELSON AND STAHL EXPERIMENT

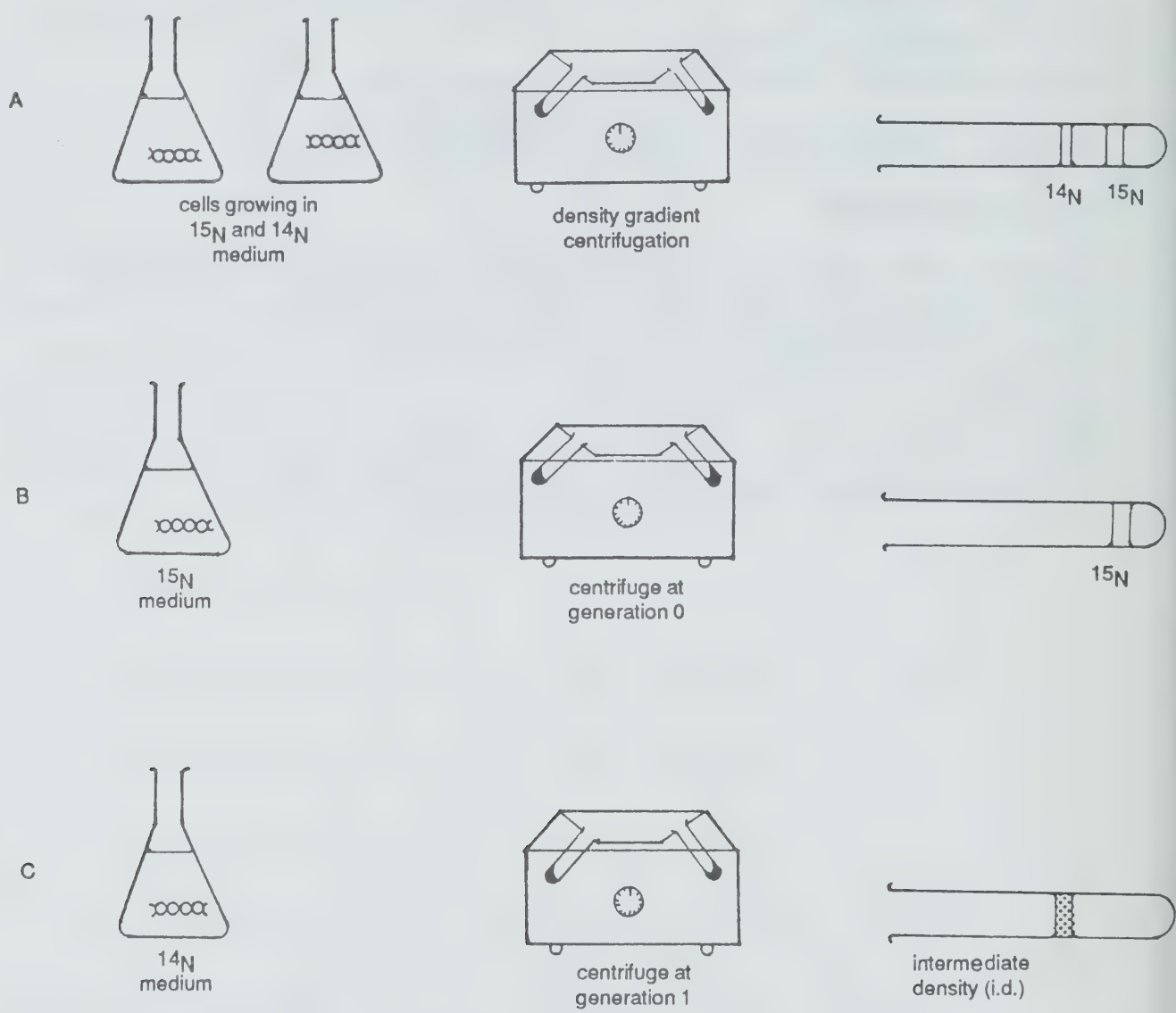


Figure 4K.22a illustrates the apparatus and technique used by M. Meselson, and F. Stahl to separate DNA molecules of two different densities. The technique, which made use of isotopes of nitrogen, is called density gradient centrifugation.

In Figure 4K.22b, cells of *E. coli*, containing DNA molecules were allowed to replicate in a medium of ^{15}N isotope. The resulting DNA, containing this isotope, was spun at high speeds in a centrifuge tube containing a solution of cesium chloride. The DNA assumed a position in a distinct band near the bottom of the tube.

The *E. coli* cells with DNA containing the ^{15}N isotope were then allowed to replicate in a medium containing ^{14}N isotopes (Figure 4K.22c). Again, the resulting DNA was centrifuged in cesium chloride and a DNA of intermediate density (i.d.) was identified.

The following are possible statements which relate to the results of the centrifugation at generation 1:

I resulting molecules contain equal proportions of ^{14}N and ^{15}N.

II The conservative method is a possible explanation for DNA replication.

III The semiconservative method is a possible explanation for DNA replication.

IV The dispersive method is a possible explanation for DNA replication.

V The resulting molecules contain unequal proportions of ^{14}N and ^{15}N.

Based on the data from this experiment only, which of the above are possibly correct statements

☐ A. I, II, and IV only

☐ B. II, III, and V only

☐ C. I and III only

☐ D. II, IV, and V only

☐ E. I, II, III, IV, and V

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmMC.03
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Meselson Stahl DNA centrifugation isotope

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

Item Focus

The student should be able to identify a possible interpretation of the experimental data of M. Meselson and F. Stahl.

Item

Refer to Figure 4K.23.

THE MESELSON AND STAHL EXPERIMENT

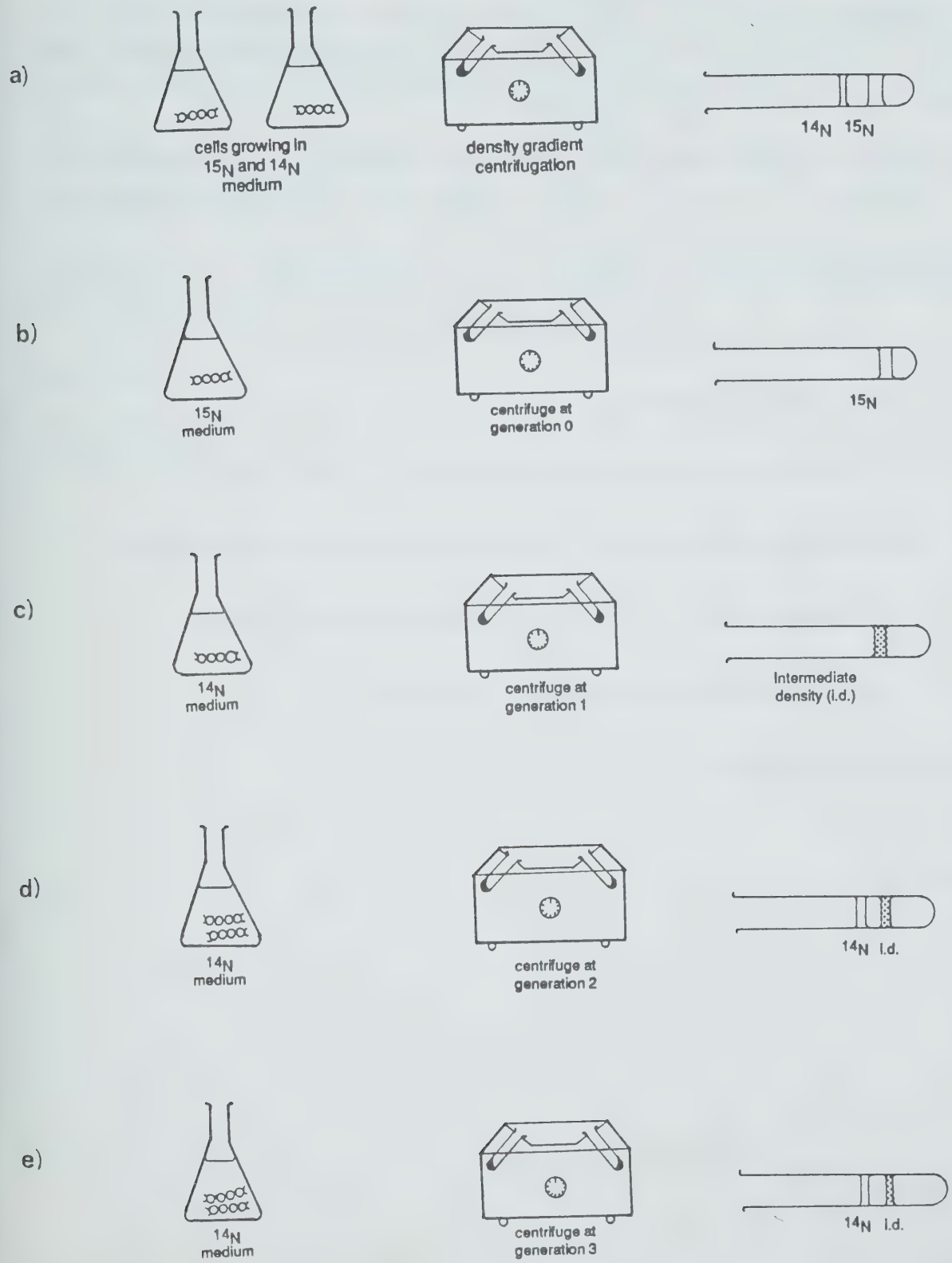


Figure 4K.23a illustrates the apparatus and technique used by M. Meselson, and F. Stahl to separate DNA molecules of two different densities. The technique, which made use of isotopes of nitrogen, is called density gradient centrifugation.

In Figure 4K.23b, cells of *E. coli*, containing DNA molecules were allowed to replicate in a medium of ^{15}N isotope. The resulting DNA, containing this isotope, was spun at high speeds in a centrifuge tube containing a solution of cesium chloride. The DNA assumed a position in a distinct band near the bottom of the tube.

The *E. coli* cells with DNA containing the ^{15}N isotope were then allowed to replicate in a medium containing ^{14}N isotopes (Figure 4K.23c). Again, the resulting DNA was centrifuged in cesium chloride and a DNA of intermediate density (i.d.) was identified.

Additional steps were carried out as illustrated in Figure 4K.23d, and e.

The results of centrifugation at generations 2 and 3 indicated that

☐ A. ^{15}N has become radioactive.

☐ B. the conservative method is a possible explanation for DNA replication.

☐ C. the semiconservative method is a possible explanation for DNA replication.

☐ D. the dispersive method is a possible explanation for DNA replication.

☐ E. no hybrid (intermediate density) DNA was formed.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmMC.04
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Meselson Stahl DNA centrifugation isotope

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

Item Focus

The student should be able to identify a correct interpretation of the experimental data of Meselson and Stahl.

Item

Refer to Figure 4K.21.

THE MESELSON AND STAHL EXPERIMENT

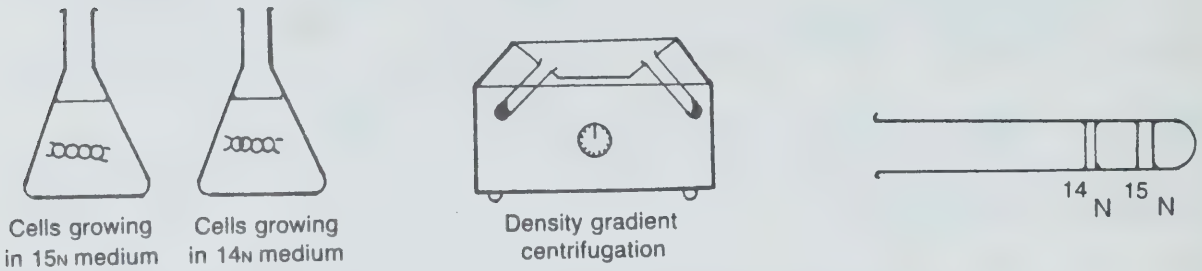


Figure 4K.21 illustrates the apparatus and technique used by Meselson, and Stahl to separate DNA molecules of two different densities. The technique, which made use of isotopes of nitrogen, is called density gradient centrifugation.

^{15}N DNA migrates lower in a centrifuge tube than ^{14}N DNA because

- [ ] A. it is more dense than ^{14}N DNA.
- [ ] B. it is less dense than ^{14}N DNA.
- [ ] C. it is radioactive, whereas ^{14}N DNA is not.
- [ ] D. it reacts with the cesium chloride in the centrifuge tube.
- [ ] E. it becomes radioactive during the experiment.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KmMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Km
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2
TOPIC: Contributions of Scientists	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: Watson-Crick DNA Chargaff

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

Item Focus

The student should be able to recognize that the Watson-Crick model of DNA was built on the work of Chargaff.

Item

The Watson-Crick model of DNA built on the work done by Chargaff (1950) by showing

- [ ] A. the double strand.
- [ ] B. the pairing of bases.
- [ ] C. the placement of phosphoric acid.
- [ ] D. the helical structure.
- [ ] E. the genetic code.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmMC.06
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5, A.7, A.11, D.3, D.4, I.13
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Meselson and Stahl DNA semi-conservative

Guideline Objective

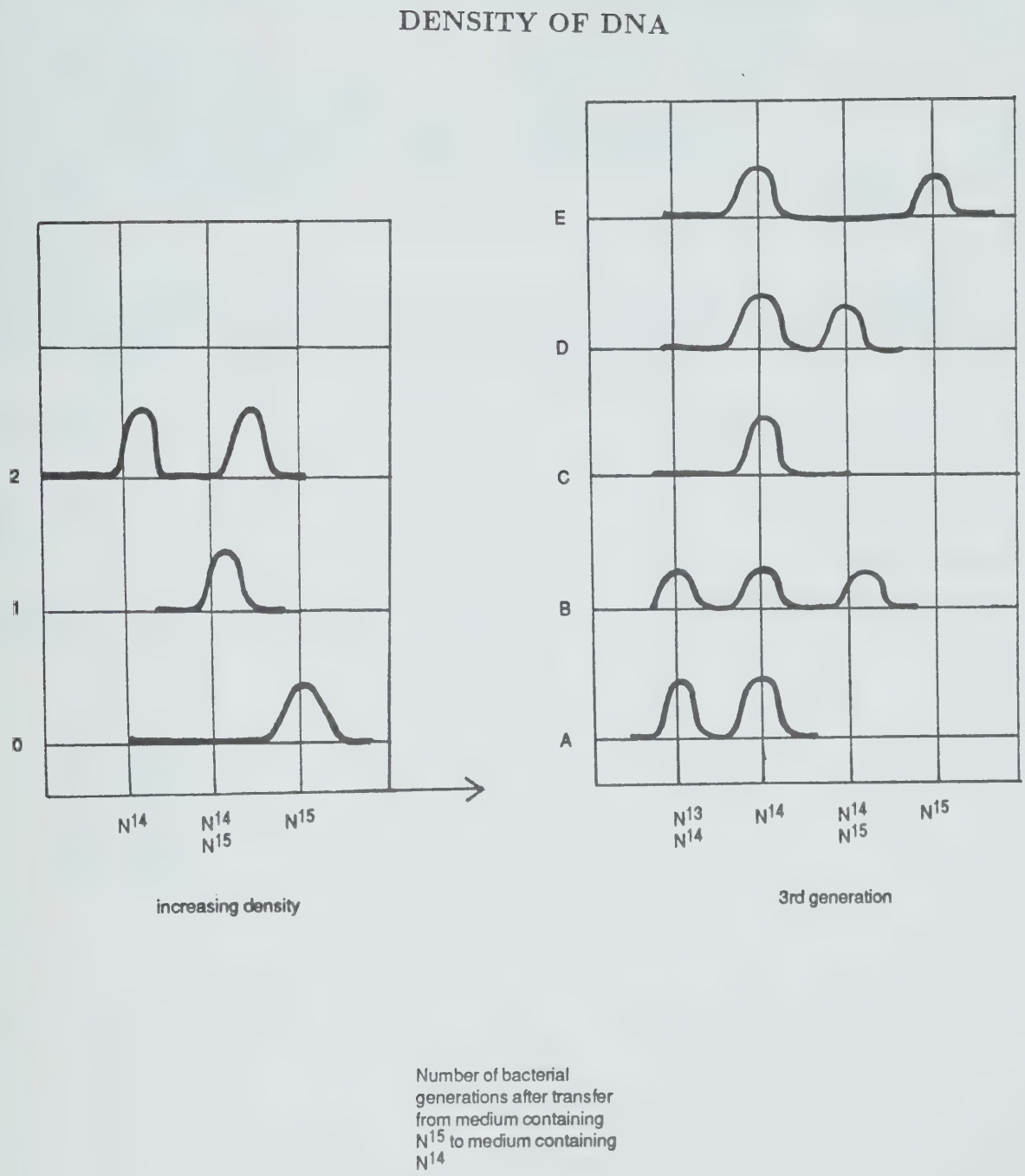
The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

Item Focus

The student should be able to relate the Meselson and Stahl experiment to the mechanism of DNA replication.

Item

Refer to Figure 4K.24.



The numbered graphs in Figure 4K.24 show the density distributions of DNA obtained from a generation of bacteria grown in ^{15}N (O) medium and from the next two successive generations grown in ^{14}N medium (1,2). The experiment is similar to one performed by Meselson and Stahl to test the semi-conservative model of DNA replication. If the following

(3) generation is also grown on ^{14}N medium, which graph from the right hand square best represents the graph of the DNA density to be expected?

- [ ] A. I
- [ ] B. II
- [ ] C. III
- [ ] D. IV
- [ ] E. V

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KmER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Km
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, I.3.
TOPIC: Contributions of Scientists	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:
KEYWORDS: geneticists	

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

Item Focus

Same as above.

Item

For each of three of the following scientists or teams, indicate how their experiments have contributed to our understanding of genetics.

W. S. Sutton
E. Chargaff
F. Griffith
J. Watson/F. Crick
T. H. Morgan

Response/Marking Scheme

Any 3 @ 3 marks each 9

Griffith:

Performed experiments on mice to investigate the effect of virulent, encapsulated pneumococci and non-virulent forms with no capsules. Found that one form of the bacteria was capable of changing the behaviour of the other form, and that the change was inheritable.

Watson/Crick:

Used the work of Chargaff and Rosalind Franklin to establish the first model of the structure of deoxyribonucleic acid that satisfied all the available evidence.

Morgan:

Pioneered work with fruit flies. Suggested an hypothesis to explain the genetic determination of sex and the inheritance of sex-linked traits.

Sutton:

Observed that chromosomes exist in homologous pairs, and proposed that genes are carried on the chromosomes. Related the behaviour of the chromosomes during meiosis to the work of Mendel.

Chargaff:

Pioneered the use of paper chromatography techniques to determine the base composition of DNA.

Possible: 9

Maximum: 9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KmER.02R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Km
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, I.3.
TOPIC: Contributions of Scientists	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: transforming principle DNA Griffith Avery

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

Item Focus

The student should be able to describe the experiment by Frederick Griffith that pointed the way to the determination of the hereditary substance, and that of Oswald Avery and others who showed that the hereditary substance was DNA.

Item

A. Describe the experiment performed by Frederick Griffith in 1926 that showed the presence of a substance that carried heredity, which he called the "transforming principle".

B. Describe the experiment in which Oswald Avery, Colin MacLeod, and Maclyn McCarty showed that the "transforming principle" was DNA.

Response/Marking Scheme

A. Griffith had showed that there are two forms of the bacterium that causes pneumonia, *Streptococcus pneumoniae*, one that is virulent (causes disease), the S-form, and one that is not, the R-form. The S-form secretes a capsule around its cells, while the R-form is unable to secrete a capsule. 3

In Griffith's experiment, three separate groups of mice were inoculated with 1

1. living non-virulent (R-form) bacteria, 1
2. heat-killed virulent (S-form) bacteria, 1
3. both living non-virulent and heat-killed virulent bacteria. 1

While mice died from the combination treatment (#3), none of the mice in groups #1 and #2 died. 3

Griffith concluded that something from the heat-killed bacteria must have transformed the non-virulent living cells into the virulent form. This something was the "transforming principle." 1

Possible: 11

Maximum: 10

B. Avery, MacLeod, and McCarty disrupted heat-killed virulent cells (S-type), extracted DNA, and highly 2

purified it. They added this DNA to living non-virulent cells (R-type). The DNA transformed the 1

living cells into the virulent S-type. They showed that the DNA was free of protein, and that if it 1

was broken up by the enzyme DNA-ase, it would not cause the transformation. They showed that the transformed 1

bacteria passed their new characteristics to their offspring through many generations. They concluded 1

that DNA must be the active hereditary material. 1

Possible: 7

Maximum: 5

Total: 15

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KmER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Km
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, C.1, C.2, D.3
TOPIC: Contributions of Scientists	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: Griffith virulent nonvirulent bacterial transformation

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

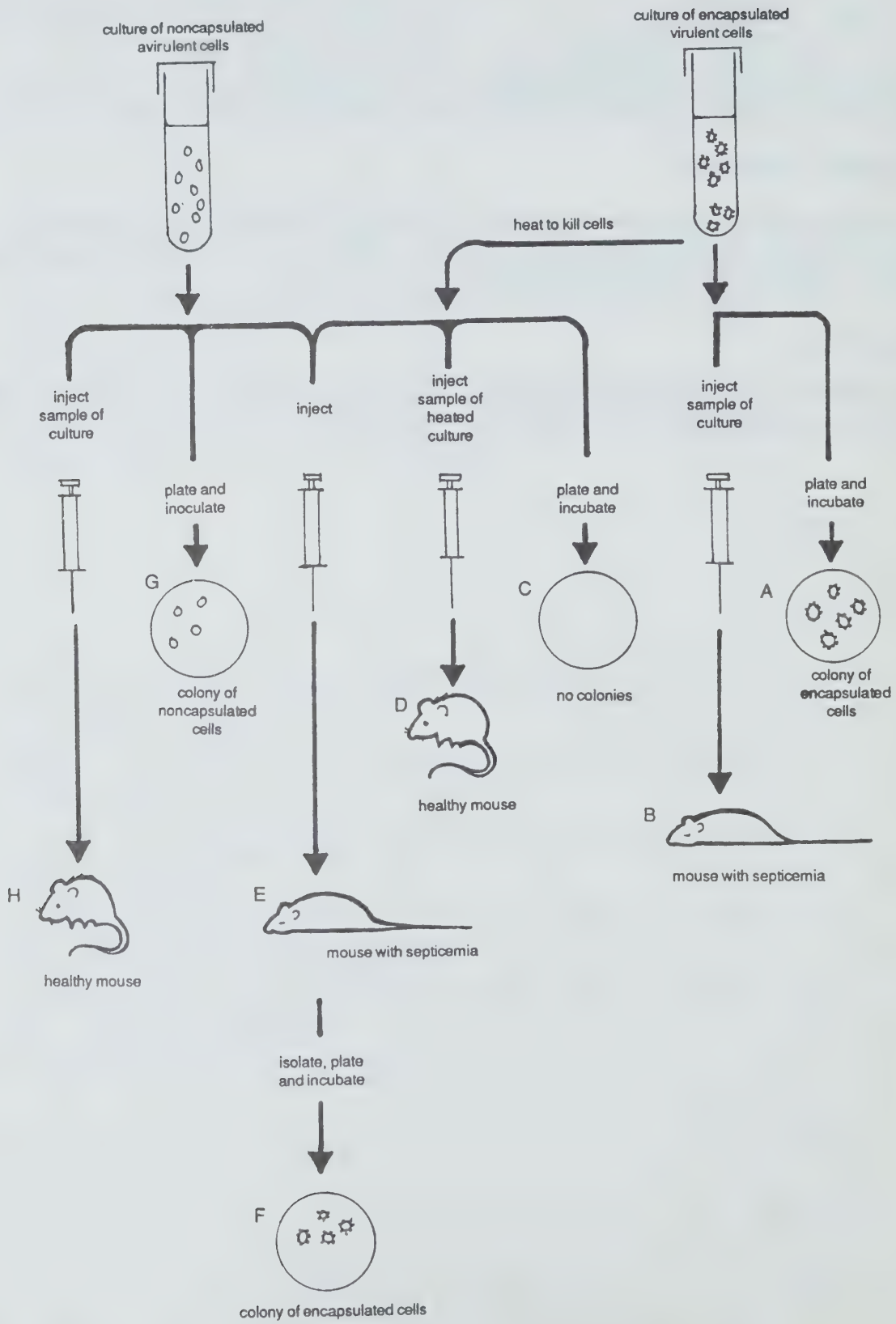
Item Focus

The student should be able to interpret and explain the experimental data of F. Griffith which has contributed to our understanding of genetics.

Item

Refer to Figure 4K.25 to answer this question.

GRIFFITH'S EXPERIMENT



During the 1920's, F. Griffith carried out a series of experiments which has contributed to our understanding of the role of DNA. Griffith discovered a form of bacterial change while studying *Diplococcus pneumoniae*, the bacterium that causes pneumonia. The results of Griffith's work are summarized in Figure 4K.25. There are two different forms of this species of bacteria: one type secretes a polysaccharide which forms a capsule around the cell and is said to be virulent, that is, capable of causing a disease. The other form does not have a capsule and is nonvirulent. Griffith inoculated one group of mice with living nonvirulent cells, another group with heat-killed virulent cells and a third group with both living nonvirulent cells and heat-killed virulent cells. Examine Figure 4K.25 and answer the questions which follow:

A. What caused mouse B to die?

B. Account for the fact that no colonies of bacteria developed in plate C.

C. Even though virulent bacteria were used, mouse D was healthy. Why?

D. Note that mouse E was injected with a mix of cells. Why did this mouse die while mice D and H remained healthy?

Response/Marking Scheme

A. Mouse B died from the disease resulting from the injection of virulent, encapsulated bacteria cells 1

B. No colonies developed in plate C because the cells were destroyed by heat. 1

C. Mouse D remained healthy because the encapsulated bacterial cells injected into the mouse were all dead. It appears that the cells must be alive to show their virulence. 2

D. Mouse E died possibly because something in the dead, encapsulated cells was passed on to the 1
noncapsulated cells transforming some of them 1
into the virulent encapsulated cells. These 1
latter cells were now capable of causing the 1
disease and killing mouse E.

Both mouse D and H remained healthy because they were only injected with either the non-capsulated or avirulent cells. 1

Possible: 9

Maximum: 7

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B041KmER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 41Km
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, C.1, C.2, D.3
TOPIC: Contributions of Scientists	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: bacterial transformation

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

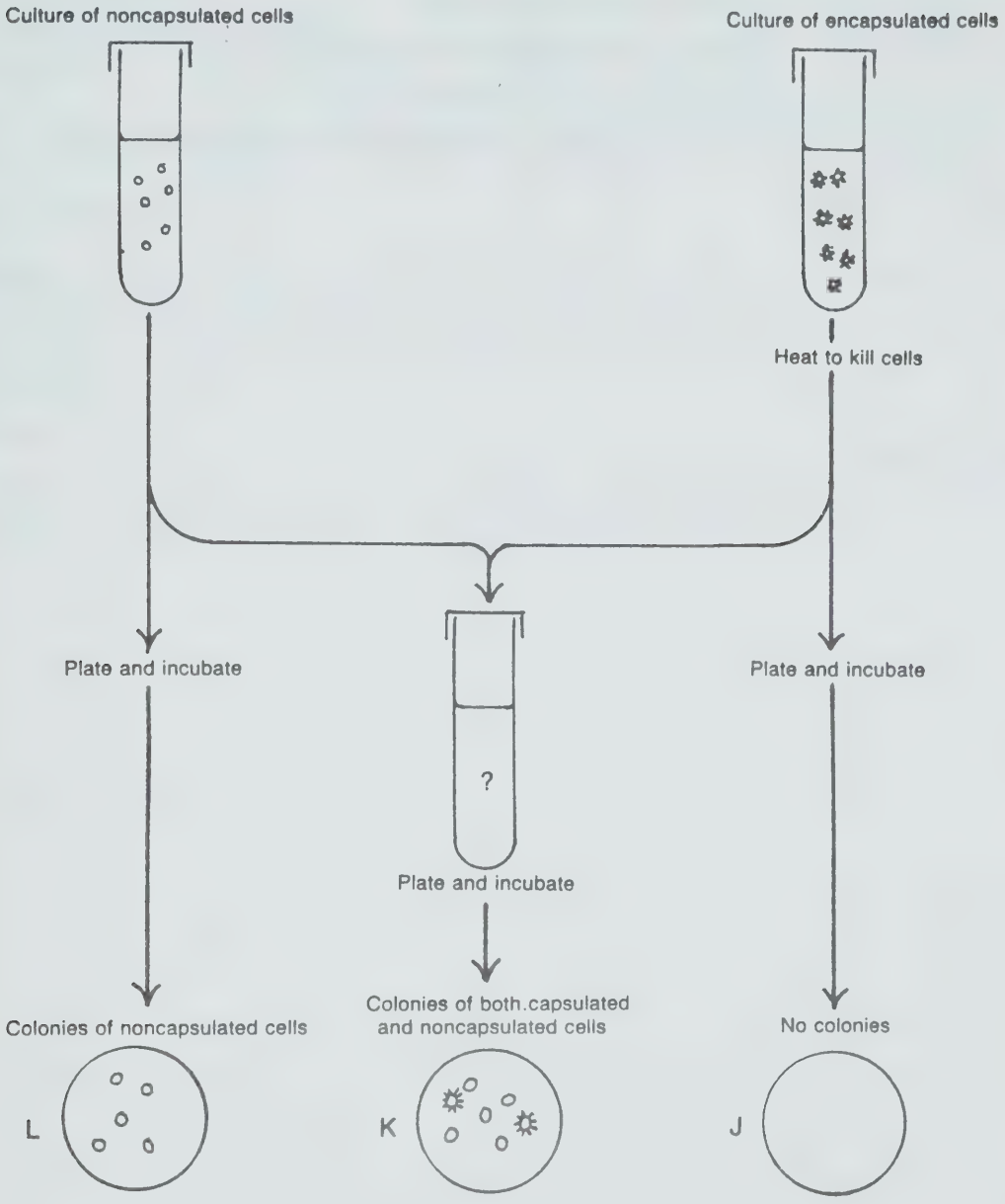
Item Focus

The student should be able to interpret and explain the experimental data of Griffith which has contributed to our understanding of genetics.

Item

Refer to Figure 4K.26.

GRIFFITH'S EXPERIMENT



During the 1920's, Griffith carried out a series of experiments which has contributed to our understanding of the role of DNA. Griffith discovered a form of bacterial change while studying *Diplococcus pneumoniae*, the bacterium which causes pneumonia. There are two different forms of this species of bacteria: one type secretes a polysaccharide which forms a capsule around the cell and is said to be virulent, that is, capable of causing a disease. The other form does not have a capsule and is nonvirulent. What can you conclude from the results of the experiment shown in Figure 4K.26?

Response/Marking Scheme

The following can be concluded from this experiment:

i. the application of sufficient heat will kill cells. 1

ii. something from the dead, encapsulated cells was passed on to the nonencapsulated cells giving rise to some cells which were encapsulated. (N.B. From this data, the students cannot state that DNA is the factor or agent.) 2

Possible: 3

Maximum: 3

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmER.05
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: DNA bacterial transformation Avery

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

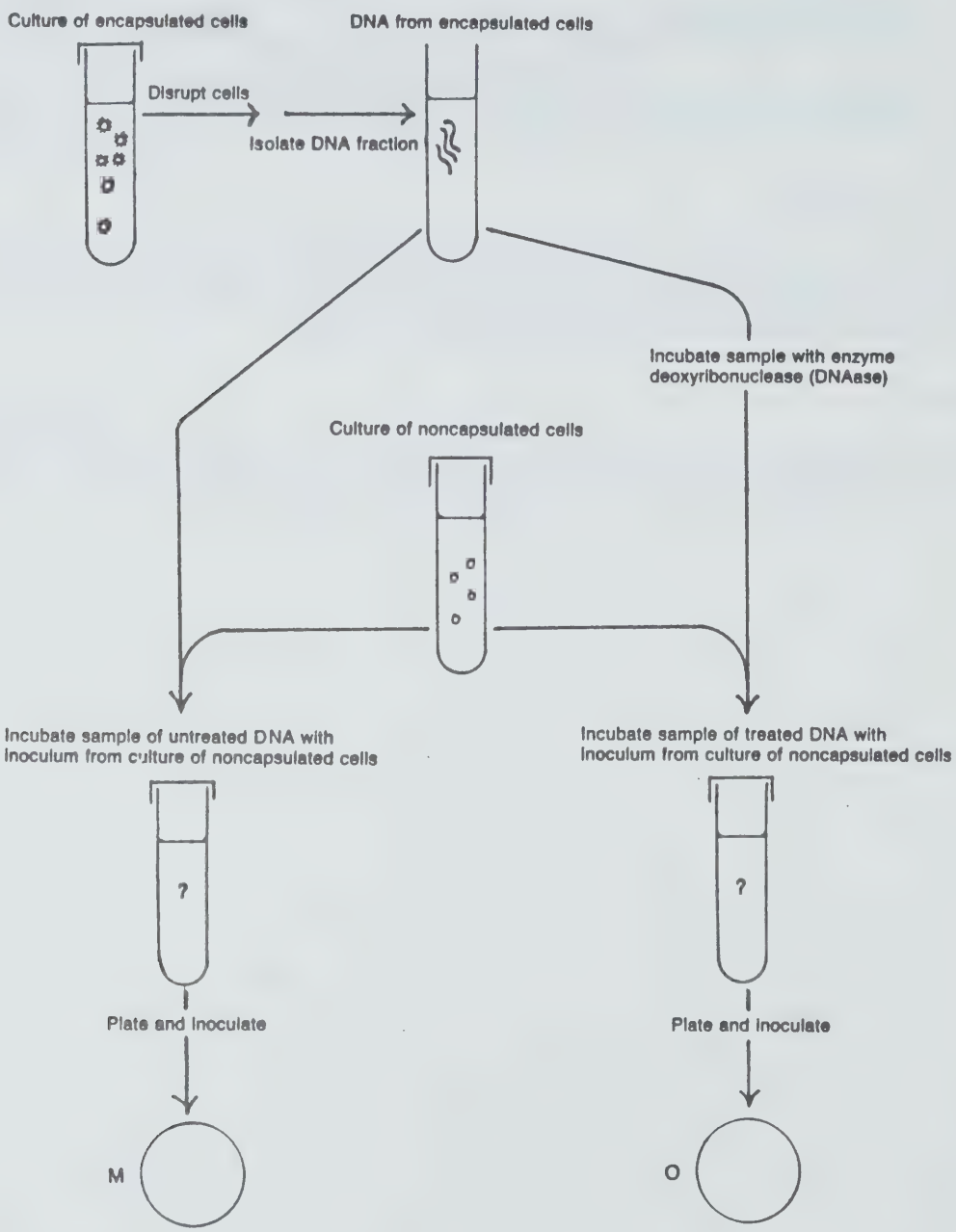
Item Focus

The student should be able to interpret and explain the experimental data of Avery, MacLeod, and McCarty which has contributed to our understanding of genetics.

Item

Refer to Figure 4K.27.

THE EXPERIMENTS OF AVERY, MACLEOD, AND M^{c}CARTY


Culture of encapsulated cells
DNA from encapsulated cells
Disrupt cells
Isolate DNA fraction
Incubate sample with enzyme deoxyribonuclease (DNAase)
Culture of noncapsulated cells
Incubate sample of untreated DNA with inoculum from culture of noncapsulated cells
Incubate sample of treated DNA with inoculum from culture of noncapsulated cells
?
?
Plate and inoculate
Plate and inoculate
M
O

Note that the encapsulated bacteria have a rough outer coat while the noncapsulated form has a smooth coat.

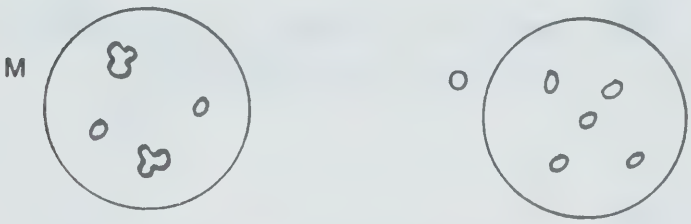
It had been known for some time that DNA and protein were components of the chromosomes of the nuclei of cells. In an attempt to determine whether or not DNA was causing bacterial transformations (changes), Avery, MacLeod, and McCarty carried out a series of experiments summarized in Figure 4K.27:

a. If the DNA was causing the bacterial transformation, sketch the contents of plates M and O as you would expect to see them in such a circumstance.

b. If the DNA was not causing the bacterial transformation, sketch the contents of plates M and O as you would expect to see them in this circumstance.

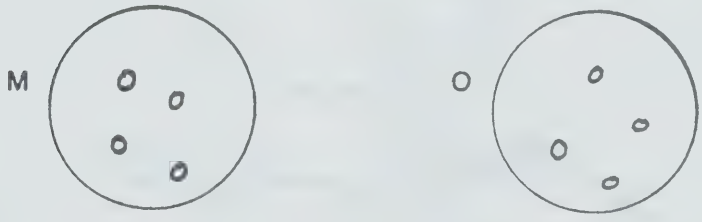
Response/Marking Scheme

a. Sketches of the contents of plates M and O if the DNA was causing the bacterial transformation:



2

b. Sketches of the contents of plates M and O if the DNA was not causing the bacterial transformation:



2

Possible: 4

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmER.06
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: bacteriophage DNA Hershey/Chase

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan contributed to our understanding of genetics.

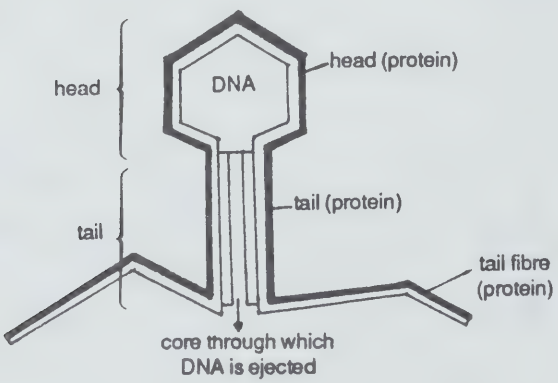
Item Focus

The student should be able to interpret and explain the experimental data of Hershey and Chase which has contributed to our understanding of genetics.

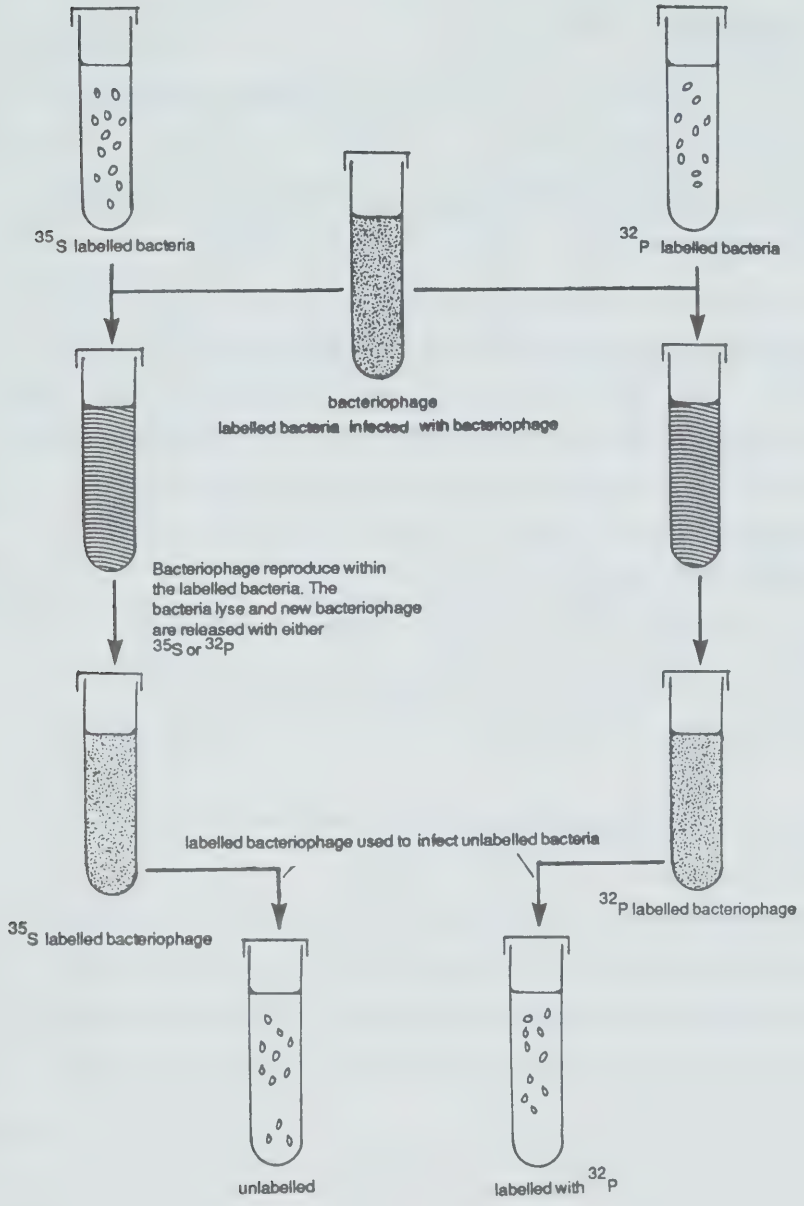
Item

Refer to Figure 4K.28.

(a) A BACTERIOPHAGE, T2



(b) THE EXPERIMENT OF HERSHEY AND CHASE


^{35}S labelled bacteria
^{32}P labelled bacteria
bacteriophage
labelled bacteria infected with bacteriophage
Bacteriophage reproduce within the labelled bacteria. The bacteria lyse and new bacteriophage are released with either ^{35}S or ^{32}P
labelled bacteriophage used to infect unlabelled bacteria
^{35}S labelled bacteriophage
^{32}P labelled bacteriophage
unlabelled
labelled with ^{32}P

In 1952, Hershey and Chase performed a set of experiments involving the bacteriophage T2, a bacterial virus, shown in Figure 4K.28a. For these experiments, they used radioactive isotopes of sulphur and phosphorus to "label" bacteria and, as indicated in Figure 4K.28b, the bacteriophage. Examine Figure 4K.28 and answer the following questions:

a. Why did the researchers use two different radioactive isotopes for their experiments?

b. Interpret the experimental results shown in Figure 4K.28.

c. What evidence was there to lead Hershey and Chase to conclude that only DNA from the bacteriophage entered the bacterium, leaving the protein sheath behind?

Response/Marking Scheme

a. A chemical analysis of the DNA of a bacteriophage indicated that phosphorus was present but sulphur 1

was absent. Sulphur was known to be present in protein of the bacteriophage but phosphorus was absent. 1

By using the two radioactive isotopes the researchers hoped to determine what part of the bacteriophage was infecting the bacteria, the DNA or the protein. 2

b. When the bacteriophage were introduced to the two labelled bacterial cultures, they picked up the radioactive isotopes and incorporated them into their molecular structure. The ^{35}S isotope was incorporated into the protein of the bacteriophage, 1

and the ^{32}P was incorporated into the DNA of the other culture. 1

The ^{35}S labelled bacteriophage did not label the bacteria because the protein coats of the phage particles were left behind when the phage entered the bacteria. 1

The ^{32}P labelled bacteriophage did label the bacteria because the DNA, containing the labelled phosphorus, entered the bacteria. 1

c. Since the labelled phosphorus was associated with the DNA of the phage particles, and only this istope was passed on to the bacteria, then only 2

the DNA of the phage particles entered the bacteria. The other labelled isotope of sulphur, associated with the protein coat, did not enter the bacteria. 2

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmER.07R
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, C.1, C.2, D.1, D.2

DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: Meselson Stahl DNA replication DNA hybrid

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

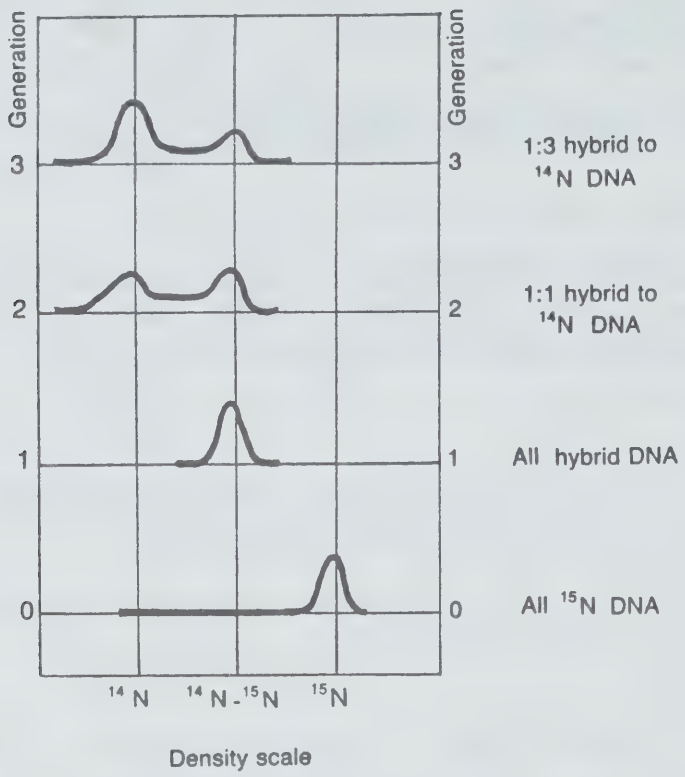
Item Focus

The student should be able to interpret and explain the experimental data of Meselson and Stahl which has contributed to our understanding of genetics.

Item

Refer to Figure 4K.29 to answer this question.

THE DENSITY OF DNA OVER 3 GENERATIONS



In 1958, Meselson and Stahl designed an experiment to determine the method by which the DNA molecule replicates. They first grew *E. coli*for several generations on a medium containing the heavy isotope of nitrogen, 15N. The organisms were collected, and after removing a sample of cells for analysis, the remainder were grown for several generations on a medium containg ^{14}N. Samples of the culture were removed after successive intervals of time that corresponded to a multiple of the generation time. The DNA was extracted from each sample of cells and its density determined. Examine the results of this experiment in Figure 4K.29 and answer the questions which follow:

A. Whereas all of the DNA of Generation 0 contained ^{15}N, all of the DNA of Generation 1 contained a hybrid of ^{15}N and ^{14}N. Account for this observation.

B. In Generation 2, there is an equal amount of hybrid DNA and ^{14}N DNA. What is the significance of this with respect to DNA replication?

C. Account for the fact that the amount of hybrid DNA in Generations 2 and 3 is the same.

D. If the amount of hybrid DNA in Generation 3 were assigned the mass unit 1, and the experiment were permitted to carry on to the next generation, how many mass units of hybrid DNA would you predict would be present in Generation 4?

E. Summarize in your own words, the results of this experiment with respect to how DNA replicates.

Response/Marking Scheme

A. Only ^{15}N was available for the production of DNA in the Generation 0, hence all of the DNA of that generation contained only that isotope. In Generation 1, the DNA was replicating in a medium of ^{14}N. 1

The DNA was replicating in such a manner that some of the original ^{15}N isotope appeared in each and every sample of the new DNA. In fact, each sample contained 1

equal amounts of the two isotopes. 1

B. It appears that there is not enough ^{15}N available to go into all of the new strands of the new DNA. This also suggests that the ^{15}N is remaining together in some form of a unit rather than dispersing equally to all new strands of DNA. 2

C. The amount of hybrid DNA is the same in Generations 2 and 3 since no more ^{15}N is available to be dispersed to all strands of the new DNA. 2

D. I would predict that there would be 4 mass units of ^{14}N DNA for every 1 mass unit of hybrid DNA. 2

E. This experiment lends evidence to support the view that DNA replicates semi-conservatively. The two 1

strands of DNA separate and replicate making use of raw materials present in the cytosol. The experimental 1

data suggests that the individual strands of DNA remain intact and serve as templates for the 1

second strand. Since no more ^{15}N isotope is added to the medium after Generation 0, the amount of this isotope remains constant for the remainder of the generations. 1

Possible: 13

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmER.08
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.7, A.10, C.2, D.3, D.5, E.2, E.5, E.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: Meselson Stahl isotopes DNA

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

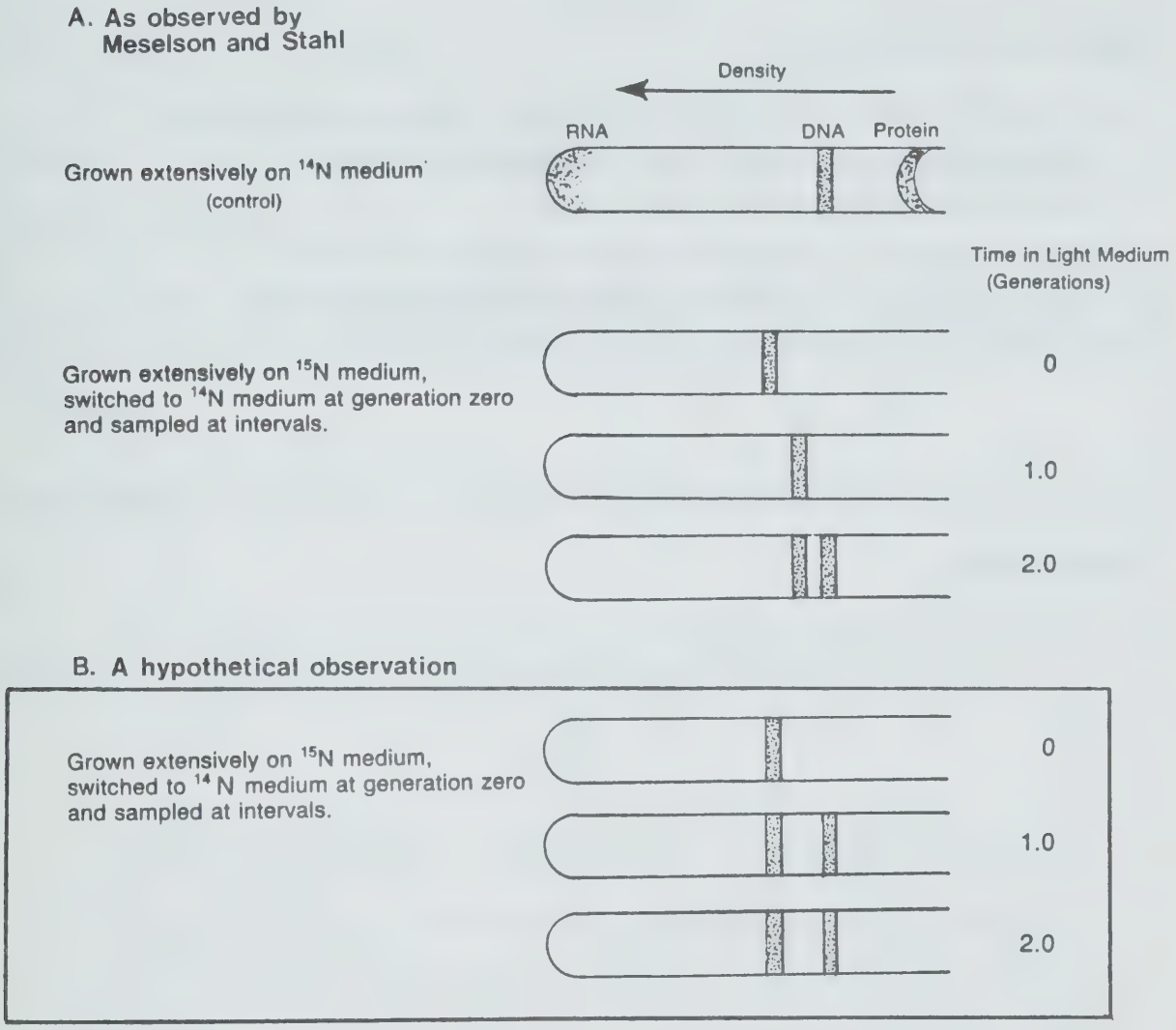
Item Focus

The student should be able to interpret the evidence from a classical experiment in genetics.

Item

Refer to Figure 4K.30.

THE RESULTS OF DENSTIY GRADIENT EXPERIMENTATION


A. As observed by Meselson and Stahl
Density
RNA
DNA
Protein
Grown extensively on ^{14}N medium (control)
Time in Light Medium (Generations)
Grown extensively on ^{15}N medium, switched to ^{14}N medium at generation zero and sampled at intervals.
0
1.0
2.0
B. A hypothetical observation
Grown extensively on ^{15}N medium, switched to ^{14}N medium at generation zero and sampled at intervals.
0
1.0
2.0

Meselson and Stahl grew bacteria in a medium in which all sources of nitrogen were of the heavy isotope, ^{15}N. They transferred the bacteria then to a medium containing only the normal ^{14}N isotope. They extracted DNA from samples taken just before the transfer and also after one and two generations had lived in the ^{14}N medium (Generation 1.0 and Generation 2.0, respectively).

The DNA samples were subjected to density gradient centrifugation, a process that allows the density of DNA to be calculated. Meselson and Stahl's results are shown in Figure 40K.30-A.

A. What conclusion did Meselson and Stahl make from their observations?

Suppose, however, that the results obtained in these experiments were those displayed in the box, Figure 4K.30-B.

B. How would our views of DNA replication have differed from those we currently hold? Explain your reasoning.

Response/Marking Scheme

A. The DNA molecule uncoils during replication, and each strand acts as a template for the synthesis of a new (complementary) strand. 3

B. The parental DNA molecule remains intact, 1

and both strands of daughter molecule are newly synthesized. 1

The results show the presence of only heavy or light DNA with no sign of the existence of molecules intermediate between the two forms. 2

Possible: 7

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmER.09
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: ER
KLOPFER: A1. A2, A3, A5, A9, A10, C2, D2, D3, D6, F1
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: DNA base pairs Chargaff

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

Item Focus

The student should be able to extend knowledge of Chargaff relationships to a new problem.

Item

DNA is said to be denatured when two strands separate under the influence of heat. Such denaturation occurs at a specific temperature. Examine the data that follows.

DATA

SOURCE OF DNA	% ADENINE	DENATURATION POINT
cattle	29.0	89°C
E. coli	25.0	90°C
Micrococcus phlei	15.0	97°C
Pneumococcus	30.5	85°C
salmon	29.5	89°C
Serratia	20.0	93°C

A. Describe, in words, any trend that appears to exist in the data.

B. Account for the trend using information gained in the biology course about the structure of DNA.

Response/Marking Scheme

A. The lower the content of adenine	1
in the DNA, the higher the denaturation point.	1
B. A low value for % adenine means a low value for adenine + thymine	1
since % adenine = % thymine	1
and a correspondingly high value for guanine + cytosine.	1
Since the guanine/cytosine pair is held together by three hydrogen bonds,	1
while the adenine/thymine pair is held by only two hydrogen bonds,	1
therefore the strands of DNA will be held together more firmly	1
as the proportion of guanine/cytosine pairs in its structure increases	1
and the denaturation point will be higher.	1
Possible:	10
Maximum:	8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Biochemical Genetics
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B041KmER.10
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.8, A.9, I.3

DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: history (DNA) DNA proteins

Guideline Objective

The student will be expected to briefly describe how the experiments of at least three biologists (e.g., Mendel, Feulgen, Muller, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan) have contributed to our understanding of genetics.

Item Focus

The student will demonstrate a knowledge of how scientific decisions were made as to the appropriateness of two competing ideas as to the nature of the genetic material (nucleic acids or proteins).

Item

Discuss the historical reluctance among scientists to accept DNA as the carrier of genetic information.

Response/Marking Scheme

From the late 19th century, both proteins and nucleic acids were known to be located inside the nucleus. It was thought that one of the two chemicals was the hereditary material.	1
One problem that had to be accounted for was the large variety of phenotypes which were controlled by the hereditary material.	1
Whatever the genetic material was, it would have to possess capability of having a very large number of different forms or structures.	1
Proteins were known to be giant polymers of amino acids.	1
DNA was known to be a giant molecule made of ribose sugars, phosphates, and four nitrogenous bases.	1
Proteins consisted of about 20 different amino acids.	1
It seemed reasonable that potentially, it was possible to make a greater variety of proteins using 20 different component parts than nucleic acids, using significantly fewer component parts.	1
	Possible: 7
	Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Contributions of Scientists
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: geneticists

INSTRUMENT CODE: B041KmMA.01R
GUIDELINE OBJECTIVE CODE: 41Km
INSTRUMENT TYPE: MA
KLOPFER: A.1, A.2, A.3, I.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The student will be expected to describe how the experiments of various biologists - e.g., Mendel, Feulgen, Mullen, Griffith, Hershey, Chase, Watson, Crick, Stahl, Meselson, Chargaff, Sutton, Morgan, contributed to our understanding of genetics.

Item Focus

The student should be able to identify the contributions listed above with the scientists who made them.

Item

The scientists listed in the table below have made significant contributions to our knowledge of genetics. Read the numbered paragraphs that follow the table, and then match the number of the paragraph with the name of the scientist in the table who made the particular contribution.

SCIENTISTS	NUMBER OF THE PARAGRAPH DESCRIBING THEIR WORK
W. S. Sutton	
A. Hershey/M. Chase	
G. Mendel	
R. Feulgen	
H. Muller	
E. Chargaff	
F. Griffith	
F. Stahl/M. Meselson	
J. Watson/F. Crick	
T. H. Morgan	

1. Performed experiments on mice to investigate the effect of virulent, encapsulated pneumococci and non-virulent forms with no capsules. Found that one form of the bacteria was capable of changing the behaviour of the other form, and that the change was inheritable.

2. Used the work of Chargaff and Rosalind Franklin to establish the first model of the structure of deoxyribonucleic acid that satisfied all the available evidence.

3. Pioneered work with fruit flies. Suggested an hypothesis to explain the genetic determination of sex and the inheritance of sex-linked traits.

4. Used DNA labelled with a heavy isotope of nitrogen in density gradient experiments to form an hypothesis regarding DNA replication.

5. Observed that chromosomes exist in homologous pairs, and proposed that genes are carried on the chromosomes. Related the behaviour of the chromosomes during meiosis to the work of Mendel.

6. Discovered that DNA was readily stained by the dye, fuchsin, leading to the realization that DNA is present in all cells, and is located in the chromosomes.

7. Used radioactive tracers in T2 phages to demonstrate that DNA, not protein, is the genetic material in phages.

8. Pioneered the use of paper chromatography techniques to determine the base composition of DNA.

9. Developed a system for detecting recessive sex-linked lethal mutations induced by X-rays.

10. carried out experiments that established the principle of independent assortment, where the traits under investigation are located on different pairs of chromosomes.

Response/Marking Scheme

SCIENTISTS	NUMBER OF PARAGRAPH
W. S. Sutton	5
A. Hershey/M. Chase	7
G. Mendel	10
R. Feulgen	6
H. Muller	9
E. Chargaff	8
F. Griffith	1
F. Stahl/M. Meselson	4
J. Watson/F. Crick	2
T. H. Morgan	3

One mark for each

Possible: 10

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Genetic Research and Technology

CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B042a-LA.01
GUIDELINE OBJECTIVE CODE: 42a
INSTRUMENT TYPE: LA
KLOPFER: A.1, A.2, A.9, B.1, D.3, E.2.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: DNA structure transcription.

Guideline Objective

Students are to be able to examine and interpret electron micrographs of chromosomes and DNA molecules.

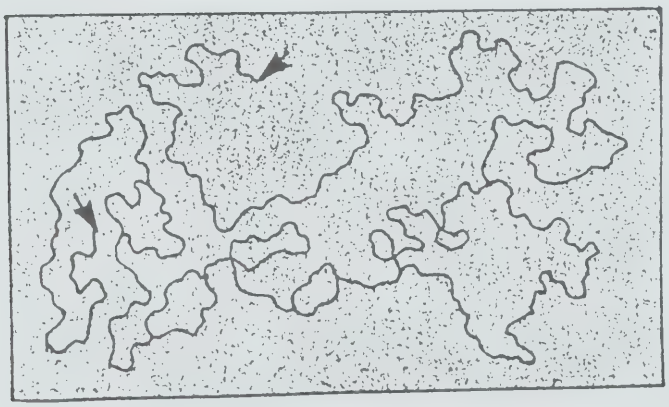
Item Focus

The student should be able to interpret an electron micrograph of DNA.

Item

Figure 42 a 3

ELECTRON MICROGRAPH



A. Identify this electron micrograph. (Figure 42 a 3)

B. Interpret the event depicted by this photograph.

Response/Marking Scheme

A. Figure 42 a 3 represents a strand of DNA.	1
B. The event is replication.	1
The four open loops occur	1
the DNA molecule has separated into two strands.	1
Each strand is synthesizing a new DNA strand	1
by pairing with nucleotide bases from the nuclear sap.	1
Possible:	6
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Biochemical Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B042b-LE.01
GUIDELINE OBJECTIVE CODE: 42b
INSTRUMENT TYPE: LE
KLOPFER: A.1, A.2, A.4, A.5, D.2, E.1, E.2, E.3.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: DNA nucleotides deoxyribose phosphate cytosine thymine adenine guanine.

Guideline Objective

Students are to be able to build models of a section of DNA and a complementary RNA molecule and/or manipulate commercially prepared models of DNA.

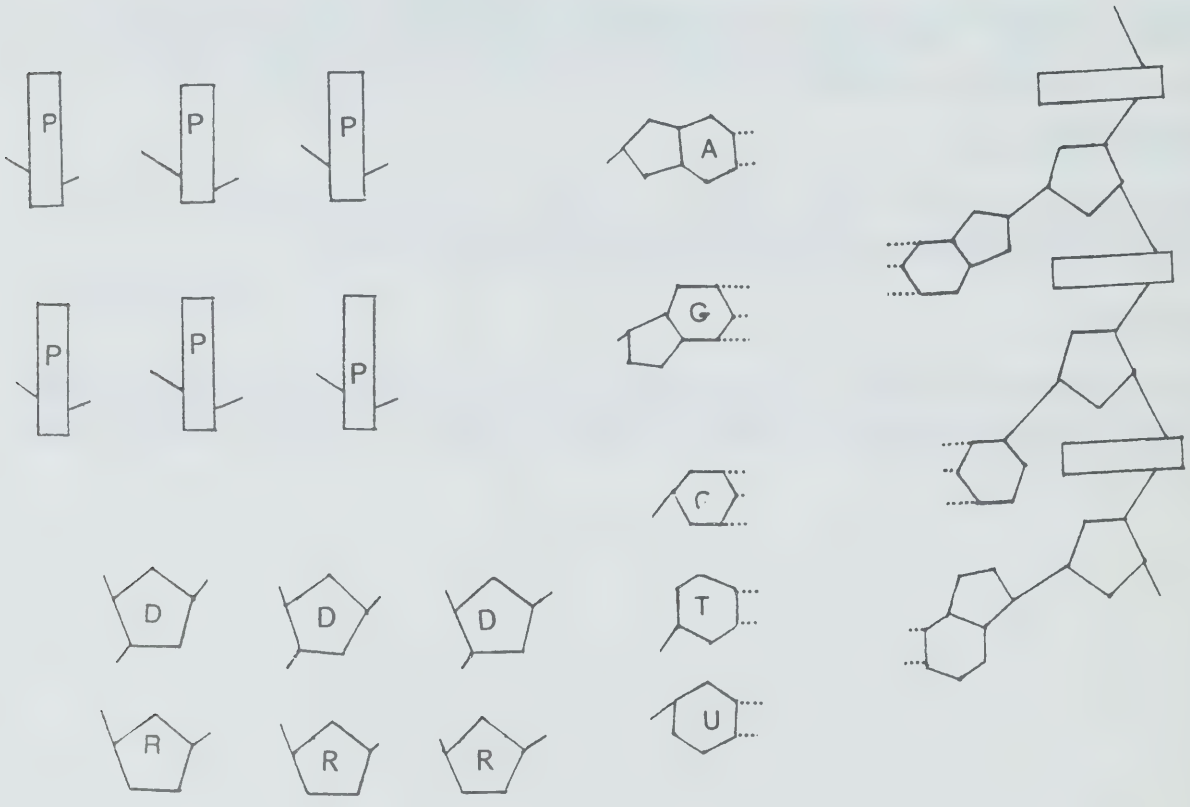
Item Focus

The student should be able to organize specific molecular components of DNA (cytosine, thymine, adenine, guanine, deoxyribose, phosphate) in order to construct a molecular model of a short segment of DNA.

Item

Using the molecular components provided (see Figure 42-2), illustrate genetic transcription. Identify each component unit, and the molecules represented by the segment before and after transcription.

Figure 42-2



Response/Marking Scheme

Student correctly assembles DNA molecule 2

C - G

G - C

T - A

Student splits DNA molecule in half 1

and constructs a complementary RNA molecule for one strand: 2

C, G, T OR G, C, U

Components identified: 6

nucleotide base, cytosine, guanine, thymine, uracil ribose sugar, phosphate

Possible: 11

Maximum: 8

Teacher Notes

Materials:

Molecular drawings (Figure 42-2) or molecular models of:

- phosphate (6)
- deoxyribose (3)
- ribose (3)
- cytosine
- guanine
- adenine
- thymine
- uracil
- a 3 nucleotide length of a half DNA

scissors

tape or glue

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B042d-MC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 42d
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Gene Mapping	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: gene map

Guideline Objective

The student will construct a gene map, given test cross information.

Item Focus

The student should be able to identify the information given on a gene map.

Item

Which of the following best outlines the information given on a gene map?

- ☐ A. the relative number of genes on the members of a pair of homologous chromosomes
- ☐ B. the potential for gene mutation
- ☐ C. the sequence and relative distance between the genes on a chromosome
- ☐ D. the position of abnormal genes
- ☐ E. the length of the chromosome in genetic units

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Gene Mapping
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B042d-LA.01
GUIDELINE OBJECTIVE CODE: 42d
INSTRUMENT TYPE: LA
KLOPFER: A.1, A.2, A.5, A.7, A.11, D.1, D.2, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: gene map

Guideline Objective

The student will construct a gene map, given test cross information.

Item Focus

Same as above.

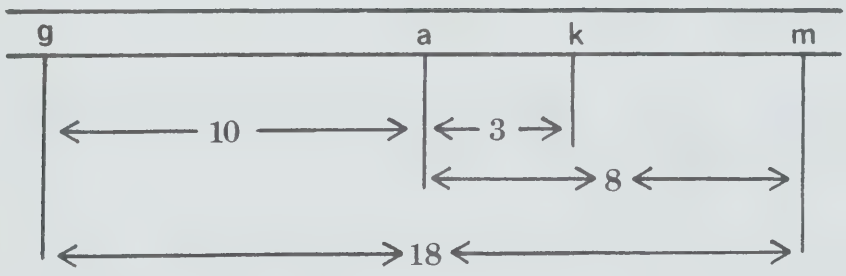
Item

From the following distances between pairs of genes, construct a gene map for the part of the chromosome on which all four traits are located:

a - g	10 units
m - g	18 units
m - a	8 units
g - k	13 units
k - a	3 units

Response/Marking Scheme

Gene map:



Possible: 5

Maximum: 5

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B042d-LA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 2d
UNIT NUMBER: 04	INSTRUMENT TYPE: LA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.4, A.7, D.1, D.2, D.3, D.4.
TOPIC: Genetic Research and Technology	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: test cross linkage chromosome mapping

Guideline Objective

Students are to be able to construct a gene map from test cross information.

Item Focus

The student should be able to determine the gene loci for certain traits by analyzing data obtained from test crosses.

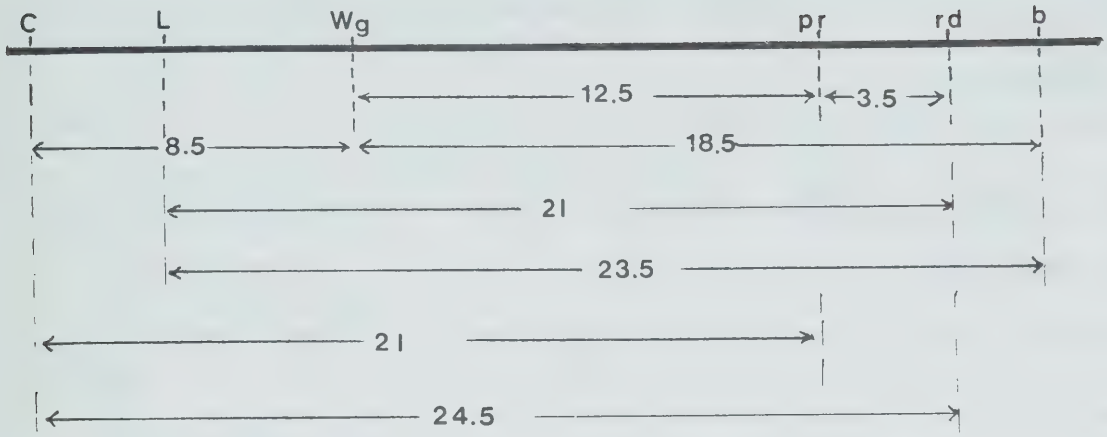
Item

The following are the recombinants obtained for genes on the same chromosome, obtained from various test crosses on *Drosophila melanogaster.*

	Use the symbols
curved wings/vestigial wings 8.5	C
curved wings/reduced bristles 24.5	Wg
reduced bristles/purple eyes 3.5	rd
black body/lobe eyes 23.5	pr
lobe eyes/reduced bristles 21	b
vestigal wings/purple eyes 12.5	L
vestigal wings/black body 18.5	
purple eyes/curved wings 21	

Determine the relative positions of the gene loci with respect to each other. Show your results on a chromosome map.

Response/Marking Scheme



Possible: 8

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Gene Mapping
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B042d-LP.01R
GUIDELINE OBJECTIVE CODE: 42d
INSTRUMENT TYPE: LP
KLOPFER: A.1, A.2, A.3, A.4, A.5, D.1, D.2, D.3.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: linkage gene map testcross

Guideline Objective

Students will be expected to construct a gene map from the testcross information.

Item Focus

The student should be able to determine the relationship of alleles that are linked on the same chromosome.

Item

In corn, yellow kernels (Y) are dominant over white (y); full kernel (F) is dominant over shrunken (f); and 13 rows of kernels on a cob (R) is dominant over 8 rows (r). In test crosses involving these traits, the following results were obtained:

Cross #1

yellow, full kernel	720
yellow, shrunken kernel	24
white, full kernel	60
white, shrunken kernel	396

Cross #2

yellow, 13 rows	368
yellow, 8 rows	48
white, 13 rows	48
white, 8 rows	336

Cross #3

full kernel, 13 rows	501
full kernel, 8 rows	12
shrunken kernel, 13 rows	39
shrunken kernel, 8 rows	448

A. For Cross #1, list the expected genotypes, and state what the phenotypes of each.

B. What mode of inheritance is shown by the test results?

C. From the data given, calculate the relative positions of the genes for colour, texture, and number of rows of kernels on the chromosome(s), and construct a gene map.

Response/Marking Scheme

A. 4

YyFf	yellow,	full	kernels
Yyff	yellow,	shrunken	kernels
yyFf	white,	full	kernels
yyff	white,	shrunken	kernels

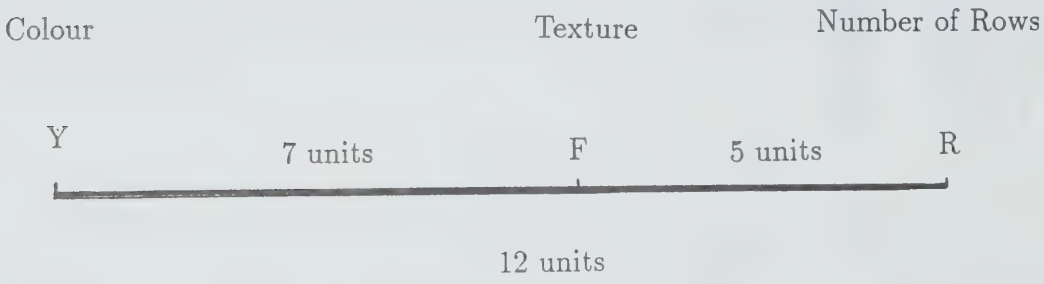
B. The genes are linked on the same chromosome. 2

C. The colour and texture genes must be 7 units apart. 1

The genes for colour and number of rows must be 12 units apart. 1

The genes for texture and number of rows must be 5 units apart. 1

Therefore the gene map: 3



Possible: 17

Maximum: 15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Gene Mapping
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B042d-LP.02
GUIDELINE OBJECTIVE CODE: 42d
INSTRUMENT TYPE: LP
KLOPFER: A.1, A.2, A.3, A.6, A.8, D.1, D.2, D.3, D.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: linkage recombinants gene map

Guideline Objective

Students will be expected to construct a gene map from the testcross information.

Item Focus

The student should be able to determine the relationship of alleles that are linked on the same chromosome.

Item

For some time, it has been known that red hair and a tendency to develop diabetes are inherited as recessive traits (alleles r and d). A recent study suggested that the genes for these two alleles might be linked on the same chromosome. A further study of children, one of whose parents was red-headed and diabetic, while the other was not, showed a ratio of 45% normal non-redheads, 43% redheaded diabetics, 3% non-redheaded diabetics, and 4% redheads without diabetes.

A. What were the genotypes of the parents?

B. What are the relative positions of the genes?

Response/Marking Scheme

A. Redheaded diabetics: rrdd	1
Non-redhead normal: RrDd	1
B. The genes are linked on the same chromosome,	2
7 gene units apart.	1
Possible:	5
Maximum:	5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Population Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B042d-LP.03
GUIDELINE OBJECTIVE CODE: 42d
INSTRUMENT TYPE: LP
KLOPFER: A.1, A.2, A.5, A.7, A.11, C.1, C.4, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: crossing over recombination linkage

Guideline Objective

Students will be expected to construct a gene map from the testcross information.

Item Focus

The student should be able to calculate the genotypes and their proportion, where there are 10% recombinants.

Item

If genes A and B are 10 units apart on the same chromosome, and recombination occurs with both parental genes, what genotypes would you expect from the following cross, and in what proportions would they occur?

$$\frac{AB}{ab} \times \frac{AB}{ab}$$

Response/Marking Scheme

Non Recombinants (90%)		Recombinants (10%)				
$\frac{AB}{AB}$	22.5%	$\frac{Ab}{AB}$	2.5%	$\frac{aB}{AB}$	2.5%	2
$\frac{AB}{ab}$	45%	$\frac{Ab}{ab}$	2.5%	$\frac{aB}{ab}$	2.5%	
$\frac{ab}{ab}$	22.5%	7 genotypes:				7

Possible: 9

Maximum: 9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Population Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B042d-LP.04
GUIDELINE OBJECTIVE CODE: 42d
INSTRUMENT TYPE: LP
KLOPFER: A.1, A.2, A.5, A.7, A.11, C.1, C.4, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: crossing over recombination linkage gene map

Guideline Objective

Students will be expected to construct a gene map from test cross information.

Item Focus

The student should be able to carry out a dihybrid cross with alleles on the same chromosome with 0.5% recombination.

Item

In chickens, the following alleles are located 0.5 units apart on the same chromosome:

C - creeper (short legs)	R - rose comb
c - normal	r - single comb

What genotypes, and how many of each would be expected among 2 000 offspring of the following cross?

$$\frac{Rc}{rC} \times \frac{rc}{rc}$$

Response/Marking Scheme

Non recombinants:

$\frac{Rc}{rc}$ 995

$\frac{rC}{rc}$ 995

Recombinants:

$\frac{RC}{rc}$ 5 Genotypes: 4

$\frac{rc}{rc}$ 5 Proportions: 4

Possible: 8

Maximum: 8

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B044b-ER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 44b
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: I.4, I.5
TOPIC: Science and Society	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Communication	TIME ALLOCATION:

KEYWORDS: biotechnology recombinant DNA issues.

Guideline Objective

The student will be aware of the application of genetic engineering to the development of new organisms and the possibility of applications to eugenics raises difficult moral and ethical problems, which will need to be considered.

Item Focus

The student will choose a statement concerning an attitude toward decision-making in biotechnology and support his or her choice.

Item

Some people think that scientists and engineers should be the ones to decide on future biotechnology in Canada (e.g., recombinant DNA, gene splicing, etc.,) because scientists and engineers are the ones who best know the facts. Others disagree. Choose one of the following and justify your choice.

A. Scientists and engineers have the training and the facts which give them a better understanding of the issue.

B. Scientists and engineers have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests.

C. Scientists and engineers have the training and facts which give them a better understanding; but the public should be either informed or consulted in making decisions.

D. The decision should be made equally; viewpoints of scientists and engineers, other specialists, and the informed public should all be considered in decisions which affect our society.

E. The government should decide because the decision is basically a political one; but scientists and engineers should give advice.

F. The public should decide because the decision affects everyone; but scientists and engineers should give advice.

G. The public should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic views on the issue and pay little attention to consequences.

Response/Marking Scheme

Selection of one of the choices. Reasons for selecting the choice must be given.

Supporting argument

Coherence

Clarity of statements

Teacher Notes

It may be that you would prefer to use this question for class discussion or debate, rather than evaluating opinions.

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3.
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: dihybrid cross

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses.

Item Focus

Same as above.

Item

In guinea pigs, black coat (B) is dominant over brown coat (b), and rough coat (R) is dominant over smooth coat (r). A cross between two guinea pigs produced 16 offspring:

6 black with rough coats, 2 brown with rough coats,

6 black with smooth coats, 2 brown with smooth coats.

What were the genotypes of the parents?

☐ A. BBRr, BbRr

☐ B. BbRr, Bbrr

☐ C. BBRR, bbrr

☐ D. BBrr, bbRR

☐ E. BBRR, Bbrr

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: dihybrid cross

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses.

Item Focus

Same as above.

Item

In green pea plants, tallness is dominant over dwarfness, and yellow seeds are dominant over green. If a fully heterozygous tall plant with yellow seeds were crossed with a dwarf plant bearing green seeds, the phenotype ratio of the offspring would be

- ☐ A. 1:1.
- ☐ B. 3:1.
- ☐ C. 9:3:3:1.
- ☐ D. 1:1:1:1.
- ☐ E. all tall plants with yellow seeds.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: Genetics	KLOPFER: A.1, A.2, F.1
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: colour blindness sex linkage

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses.

Item Focus

The student should be able to solve problems involving sex linkage.

Item

If a colour blind man and a woman who is a carrier of colour blindness have a son, what are the chances that their son will be colour blind?

- ☐ A. 0
- ☐ B. 25%
- ☐ C. 50%
- ☐ D. 75%
- ☐ E. 100%

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, F.1
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: homozygous testcross

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses.

Item Focus

The student should be able to solve problems involving the use of a testcross.

Item

A farmer bought a bull that was said to be homozygous hornless. To be sure that this statement was true, he performed a test cross between the bull and a horned cow. If the bull were indeed homozygous hornless, the offspring from the testcross would be

- [ ] A. half horned, half hornless.
- [ ] B. all horned.
- [ ] C. in a ratio of 3 hornless to 1 horned.
- [ ] D. in a ratio of 3 horned to 1 hornless.
- [ ] E. all hornless.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, F.1
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: phenotype ABO blood groups

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses.

Item Focus

The student should be able to solve problems involving multiple alleles.

Item

If all four possible blood types are represented in the offspring of the same parents, the phenotypes of the parents must be

- ☐ A. both type AB.
- ☐ B. type AB and type O.
- ☐ C. both type O.
- ☐ D. type A and type B.
- ☐ E. type B and type O.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, F.1
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: sex-linked dominant

Guideline Objective

The student should be able to solve problems involving mono- and dihybrid crosses and sex-linkage.

Item Focus

Same as above.

Item

In *Drosophila*, eye colour is a sex-linked characteristic, with red eyes dominant over white eyes. Which of the following would result from a cross between a white-eyed female (XX) and a red-eyed male (XY)?

☐ A. All of the females would be red-eyed and all of the males would be white-eyed.

☐ B. All of the females would be white-eyed and all of the males would be red-eyed.

☐ C. All of the offspring would be pink-eyed.

☐ D. All of the offspring would be red-eyed.

☐ E. All of the offspring would be white-eyed.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, C.2
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: linkage	

Guideline Objective

The student should be able to solve problems using monohybrid and dihybrid crosses.

Item Focus

Same as above.

Item

Marijuana plants with green, shiny leaves are crossed with homozygous recessive yellow fuzzy leaved plants. The following results were obtained:

32 with green, fuzzy leaves
404 with green, shiny leaves
526 with yellow, fuzzy leaves
38 with yellow, shiny leaves

The explanation for this type of inheritance would be that

- [ ] A. the genes for leaf colour and texture are on the same chromosome.
- [ ] B. crossing over has occurred.
- [ ] C. the green,shiny-leaved plants must be heterozygous.
- [ ] D. this is a testcross.
- [ ] E. all of the above are correct.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, C.2
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: dihybrid cross

Guideline Objective

The student should be able to solve problems using mono- and dihybrid crosses.

Item Focus

Same as above.

Item

In guinea pigs, black coat, B, is dominant over brown coat, b, and rough coat, R, is dominant over smooth coat, r. A cross between two individuals results in 16 offspring with black, rough coats; 6 with brown, rough coats; 6 with black, smooth coats; and 2 offspring with brown, smooth coats. The genotypes of the parents were probably

- ☐ A. BBRr × BbRr.
- ☐ B. BbRr × Bbrr.
- ☐ C. BBRR × bbrr.
- ☐ D. BBrr × bbRR.
- ☐ E. BbRr × BbRr.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: sex chromosomes sex ratio

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses.

Item Focus

The student should be able to predict the theoretical sex ratio in humans.

Item

If a couple have had 2 boys and a girl, what are the chances that their next child will be a girl?

- [ ] A. 25%
- [ ] B. 33%
- [ ] C. 50%
- [ ] D. 66%
- [ ] E. 100%

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: meiosis homologous chromosomes

Guideline Objective

The student should be able to describe the stages of meiosis and its role in diploid organisms.

Item Focus

The student should be able to recognize that chromosomes occur in homologous pairs in cells, except in gametes.

Item

In which of the following do chromosomes NOT occur in homologous pairs?

- ☐ A. somatic cells
- ☐ B. body cells
- ☐ C. fertilized cells
- ☐ D. gametes
- ☐ E. zygotes

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.11
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: meiosis zygote gamete

Guideline Objective

The student should be able to describe the stages of meiosis and its role in diploid organisms.

Item Focus

The student should be able to identify the effect of meiosis on the number of genes in a gamete.

Item

Which one of the following expresses the ratio of the number of genes in a zygote compared to the number in a gamete of the same species?

- ☐ A. 3:1
- ☐ B. 2:1
- ☐ C. 1:1
- ☐ D. 1:2
- ☐ E. 1:3

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.12
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.3
TOPIC: Review of Mitosis and Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: mitosis meiosis synapse crossing-over tetrad

Guideline Objective

The student should be able to distinguish between mitosis and meiosis in terms of the location, process, purpose, and end products.

Item Focus

The student should be able to identify a feature of mitosis that is different from meiosis.

Item

Four of the following are features of the process of meiosis and only one is a feature of mitosis. Which one is a feature of mitosis?

- ☐ A. Two divisions occur before the process is complete.
- ☐ B. Daughter cells are genetically identical.
- ☐ C. Crossing over occurs.
- ☐ D. Tetrad formation takes place.
- ☐ E. Homologous chromosomes come together and synapse.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.13
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.3
TOPIC: Review of Mitosis and Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: mitosis meiosis synapse homologous chromosomes

Guideline Objective

The student should be able to distinguish between mitosis and meiosis in terms of the location, process, purpose, and end products.

Item Focus

The student should be able to identify a feature of meiosis that is different from mitosis.

Item

Four of the following are features of the process of mitosis and only one is a feature of meiosis. Which one is a feature of meiosis?

- ☐ A. Only one division occurs before the process is complete
- ☐ B. A constant chromosome number is maintained from parent to daughter cell
- ☐ C. Daughter cells are genetically identical
- ☐ D. It is involved in the growth, regeneration, and embryonic development of sexually reproducing organisms
- ☐ E. Homologous chromosomes come together and synapse.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.14
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: homologous haploid somatic

Guideline Objective

The student will be expected to understand the concepts of mitosis and meiosis.

Item Focus

The student should be able to identify the number of chromosomes in a haploid cell.

Item

An organism has 12 homologous pairs of chromosomes in each somatic cell. Which of the following would be the haploid number of chromosomes for the organism?

- ☐ A. 48
- ☐ B. 36
- ☐ C. 24
- ☐ D. 12
- ☐ E. 6

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Meiosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-MC.15
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

The student will be expected to distinguish between mitosis and meiosis.

Item Focus

The student should be able to identify the location of meiosis in a human.

Item

Meiosis, in humans

- [ ] A. is completed in the ovum during fertilization.
- [ ] B. results in identical daughter cells.
- [ ] C. results in diploid cells.
- [ ] D. occurs in somatic cells only.
- [ ] E. results in 4 female gametes.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.16
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Cellular Genetics	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: centrosomes chromosomes centriole homologous pair

Guideline Objective

The student will be expected to distinguish between mitosis and meiosis.

Item Focus

The student should be able to identify critical events in the process of meiosis.

Item

Which of the following occurs in an animal cell during meiosis, but not during mitosis?

☐ A. The centromeres separate.

☐ B. The chromosomes gradually become shorter and thicker.

☐ C. The centrioles move to opposite poles.

☐ D. The chromosomes become double stranded, with the strands joined by a common centromere.

☐ E. The members of each homologous pair of chromosomes become closely associated on a spindle fibre.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.17
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3.
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: meiosis gamete crossing over random assortment

Guideline Objective

The student will describe two ways in which meiosis increases genetic variability in gametes.

Item Focus

The student should be able to identify the names of two processes that contribute to the genetic variability in gametes.

Item

During meiosis, genetic variability in the gametes is achieved by

- ☐ A. transcription and translation.
- ☐ B. replication and transcription.
- ☐ C. crossing over and random assortment.
- ☐ D. crossing over and fertilization.
- ☐ E. replication and random assortment.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Meiosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-MC.18
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: chromatids

Guideline Objective

The student will be expected to distinguish between mitosis and meiosis.

Item Focus

The student will be able to identify a stage of meiosis from its description.

Item

A mammalian cell contains five chromosomes, each composed of two chromatids. The chromosomes are lined up across the equatorial plate. The stage of cell division the cell is most likely to be in is

- ☐ A. anaphase of mitosis.
- ☐ B. metaphase II of meiosis.
- ☐ C. anaphase I of mitosis.
- ☐ D. metaphase of mitosis.
- ☐ E. metaphase I of meiosis.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.19
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: chromosomes homologous

Guideline Objective

The student will describe the special behaviour of homologous chromosomes during prophase of meiosis 1.

Item Focus

The student should be able to identify gametes as special cells in which chromosomes do not occur in homologous pairs.

Item

In which of the following do chromosomes NOT occur in homologous pairs?

- [ ] A. somatic cells
- [ ] B. body cells
- [ ] C. fertilized cells
- [ ] D. gametes
- [ ] E. zygotes

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.20
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, C.2
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: crossing over	

Guideline Objective

The student will be expected to explain the results of meiosis.

Item Focus

The student should be able to recognize a situation in which crossing over is taking place.

Item

Two dominant alleles, A and B, are on one chromosome and the two recessive alleles, a and b, occur on the second chromosome of a pair. The combination of Ab and aB occurs in the gametes by

- [ ] A. crossing over.
- [ ] B. sex linkage.
- [ ] C. lack of dominance.
- [ ] D. nondisjunction.
- [ ] E. dihybrid cross.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Meiosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-MC.21
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: crossing over meiosis homologous allele

Guideline Objective

The student should be able to explain how crossing over occurs.

Item Focus

The student should be able to identify the conditions necessary for crossing over.

Item

Which of the following statements are true of crossing over, during meiosis? (Assume that no linkage is involved.) Crossing over

I occurs while the chromosomes are in synapsis during the first prophase.

II occurs between chromatids in the tetrad.

III involves only two of the four chromatids.

IV is genetically significant only if the members of a homologous pair of chromosomes possess different alleles.

V exchanges genetic material between non-homologous chromosomes.

Select your response from the following

☐ A. I, II, and IV only

☐ B. I, II, III, IV, and V

☐ C. III, IV, and V only

☐ D. I, III, and IV only

☐ E. IV, and V only.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.22
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: meiosis haploid diploid

Guideline Objective

The student should be able to explain the term reduction division as applied to anaphase I of meiosis.

Item Focus

The student should be able to identify the products of reduction division at telophase I of meiosis.

Item

Which of the following would you find at the end of the telophase I stage of meiosis?

- [ ] A. one haploid cell
- [ ] B. two haploid cells
- [ ] C. four haploid cells
- [ ] D. one diploid cell
- [ ] E. two diploid cells

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Sex Determination
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-MC.23
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: sex determination

Guideline Objective

The student will explain how sex is determined in chickens, bees, fruit flies, and humans.

Item Focus

The student should be able to identify chromosomes involved in human sex determination.

Item

The cells of a genetically normal human female are characterized by

- [ ] A. the presence of Y chromosomes.
- [ ] B. the absence of Barr bodies.
- [ ] C. the presence of more X chromosomes.
- [ ] D. the presence of an homologous pair of X chromosomes.
- [ ] E. the secondary sexual characteristics.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-MC.24
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: MC
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.6, A.8
TOPIC: Review of Linkage	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: linkage	

Guideline Objective

The student should be able to recognize when two genes are linked on the same chromosome.

Item Focus

Same as above.

Item

A research study showed that 2% of all non-diabetic children have red hair, but the percentage of redheads among diabetic children is 6.7%. This study suggests that

☐ A. all redheads are predisposed to diabetes.

☐ B. diabetes is a sex-linked trait.

☐ C. the genes for diabetes and red hair are linked.

☐ D. the percentage of crossing over on this chromosome is 6.7%.

☐ E. the genes are 6.7 gene units apart.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Population Genetics
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B048a-ER.01
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.8, A.10, C.2, D.5.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Punnett square sex ratio

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics.

Item Focus

The student will, using a diagram, show how males determine the sex of their offspring in humans and why the probability of a male and female offspring is equal.

Item

In humans, some research suggests that fast-moving sperm give rise to male offspring. Some scientists are interested in refining laboratory procedures for separating fast-moving sperm from slow-moving sperm, prior to artificial insemination. This would allow parents to choose the sex of their offspring.

A. Construct a Punnett square to show the probable sex ratio among human offspring.

B. On your Punnett square diagram, indicate a sperm that would be fast-moving, and one that would be slow- moving.

C. Among human infants, slightly more males are born than females. Evaluate this statement in the light of the information presented above. Then state, in a single sentence, an hypothesis to account for the unequal sex ratio at birth.

Response/Marking Scheme

A. and B. Punnett square: 2

	MALE GAMETES	
	slow-moving X	fast-moving Y
FEMALE X	XX	XY
GAMETES X	XX	XY

2

Genotypes: 1

Expected ratio: 50% females (XX): 50% males (XY) 1

Possible: 6

Maximum: 6

C. The statement is consistent with the hypothesis, 1

since the faster-moving sperm should carry the Y chromosomes, and reach the ovum before the slow- moving sperm bearing X chromosomes. 1

Therefore, more of the ova fertilized should contain Y chromosomes, and should result in male offspring. 1

Hypothesis:

Because the Y chromosome is smaller than the X chromosome, sperms carrying a Y chromosome may have less mass than sperms carrying the X chromosome, allowing them to move faster.

(Accept any other suitable hypothesis) 3

Possible: 6

Maximum: 4

Total: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Mendelian Genetics
CURRICULAR EMPHASIS: Nature of Science
KEYWORDS: multiple alleles

INSTRUMENT CODE: B048a-ER.02
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.10, A.11, B.2, D.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex- limited inheritance, sex linkage, and population genetics.

Item Focus

The student should be able to solve a problem involving multiple alleles.

Item

In wheat, the complete range of seed colour extends from a very dark red, through dark red, medium red, light red to white. It has been determined that these colours result from the interaction of two pairs of genes for colour, A′A, and B′B. Complete the following table to explain this mode of inheritance.

PHENOTYPE	NUMBER OF ALLELES FOR COLOUR	GENOTYPES
very dark red	4	
dark red	3	
medium red	2	
light red	1	
white	0	

Response/Marking Scheme

Since only 2 pairs of genes yield 5 shades of colour, the alleles must have an additive effect.

PHENOTYPE	No. of ALLELES	GENOTYPES	
very dark red	4	$A'A'B'B'$	1
dark red	3	$A'AB'B', A'A'B'B$	1
medium red	2	$A'A'BB, A'AB'B, AAB'B'$	1
light red	1	$A'ABB, AAB'B$	1
white	0	$AABB$	1

Possible: 5

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-ER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: crossing over	

Guideline Objective

The student will describe two ways in which meiosis increases genetic variability in gametes.

Item Focus

The student should be able to describe crossing over and indicate the biological significance of the process.

Item

A. Define the term crossing over.

B. Describe the stage in cell division during which crossing over occurs.

C. State the biological significance of crossing over.

Response/Marking Scheme

A. Crossing over is the exchange of parts of their length by non-sister chromatids of a tetrad (an homologous pair of double-stranded chromosomes). 3
This results in a rearrangement of the genetic material. 1

B. Crossing over occurs in (the pachytene stage of) prophase I of meiosis. 1
The two double-stranded chromosomes forming each tetrad are closely coiled together and are randomly arranged on the spindle fibres. 2

C. Crossing over is one of the mechanisms which eventually leads to variation between different members of a species. 1
These variations make it possible for a species to adapt to a changing environment by means of natural selection. 2

Possible: 10

Maximum: 8

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Meiosis
CURRICULAR EMPHASIS: Communication
KEYWORDS: crossing over

INSTRUMENT CODE: B048a-ER.04
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will describe two ways in which meiosis increases genetic variability in gametes.

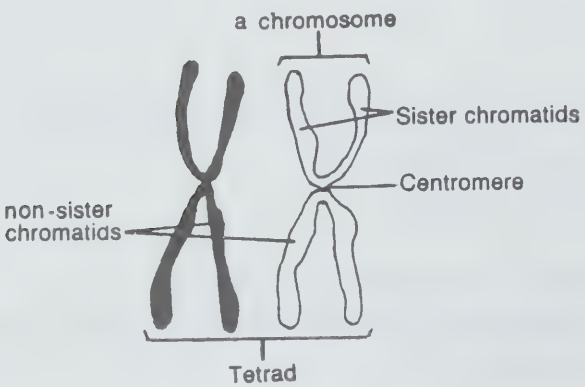
Item Focus

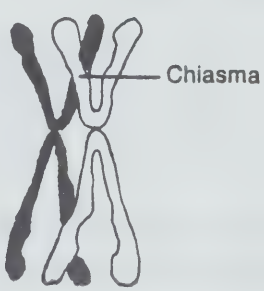
The student should be able to illustrate the process of crossing over.

Item

By means of a series of labelled diagrams, illustrate the process of crossing over. Include the following labels on your diagrams: sister chromatids, non-sister chromatids, centromere, chromosome, tetrad, chiasma, and recombinants.

Response/Marking Scheme





Labels: 7

Diagram: 3

Total: 10

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-ER.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: crossing over non-sister chromatids

Guideline Objective

The student will describe two ways in which meiosis increases genetic variability in gametes.

Item Focus

The student should be able to describe the significance of crossing over to an organism.

Item

A. During meiosis, what is the significance of crossing over when it occurs between non-sister chromatids?

B. What is the significance to the organism if crossing over occurs between sister chromatids?

Response/Marking Scheme

A. Non-sister chromatids are homologous to each other. 1

At each locus, the gene is the same, but the alleles are not necessarily the same. 1

Thus, considering the large number of loci involved, exchanging parts of their length causes a significant rearrangement of these alleles. 1

At the end of crossing over, each chromatid of a tetrad will have a unique genetic arrangement. 1

B. Sister chromatids are identical to each other 1

i.e., at each locus the gene and the alleles are the same. 1

Thus, exchanging parts of their lengths would not alter the arrangement of alleles. 1

Possible: 7

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-ER.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Review of Meiosis	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: genetic variation random assortment gametes diploid

Guideline Objective

The student will describe two ways in which meiosis increases genetic variability in gametes.

Item Focus

The student should be able to describe the process of random assortment in gamete formation.

Item

A. Define the term 'random assortment'.

B. Explain the significance of random assortment with respect to genetic variation of gametes.

C. With the aid of diagrams and notes, explain how random assortment is achieved in the gametes of an organism whose diploid (2n) number of chromosomes is 4. (Let A^mA^f and B^mB^f represent the two pairs of chromosomes, where the superscripts, m and f, represent the chromosomes received from the mother and the father.)

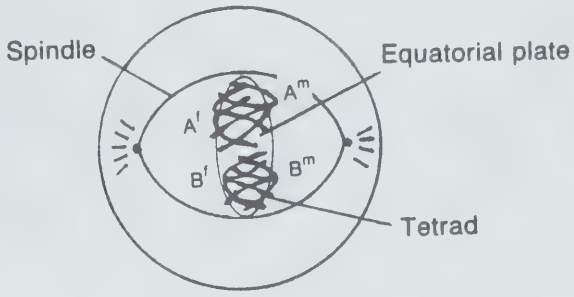
Response/Marking Scheme

A. Random assortment refers to the fact that at the end of the extended prophase of the first meiotic division, the partially separated tetrads (homologous pairs of double-stranded chromosomes) become randomly arranged across the equatorial plate of the spindle. 2

B. This leads to the possibility of different combinations of maternal and paternal chromosomes in the gametes 2
which occurs when the members of each tetrad separate during anaphase I. 1

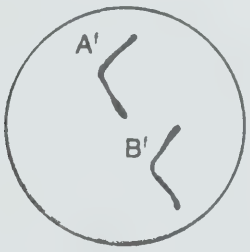
C. The organism has two homologous pairs of chromosomes. 1
One member of each pair comes from each parent. 1

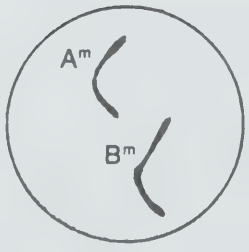
Thus, one possible arrangement at metaphase I could be:



2

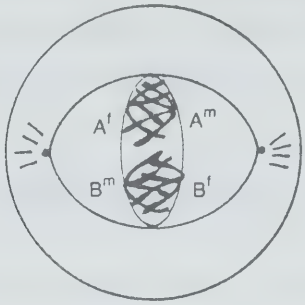
This eventually leads to gametes containing





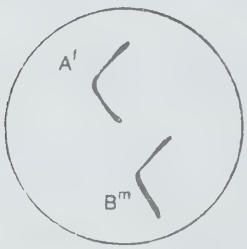
2

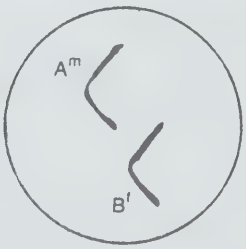
The other possible arrangement at metaphase I could be:



2

This arrangement eventually leads to gametes containing:





2

Thus, solely as a result of random assortment, four different kinds of gametes could be formed. 1

Possible: 16

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-ER.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.9
TOPIC: Review of Sex Determination	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: sex determination chromosomal abnormalities syndrome Turner's Klinefelter's

Guideline Objective

The student will explain how sex is determined in chickens, bees, fruit flies, and humans.

Item Focus

Same as above.

Item

Explain how sex is determined genetically in human beings. Support your answer with evidence from abnormal chromosomal arrangements.

Response/Marking Scheme

In normal human females, sex is determined by the presence of an homologous pair of sex chromosomes (XX)	1
In normal human males, sex is determined by a non-homologous pair of sex chromosomes (XY)	1
The presence of the Y chromosome appears to determine maleness	1
This hypothesis is supported by observations of abnormal sex chromosome arrangements in relation to the sex of the individual	1
e.g., XXX female (sterile)	
XO female (Turner's syndrome)	
XXY male (Klinefelter's syndrome)	
XXXY male	
XYY male	2
The significance being that,	
people with Y chromosome are male	1
people without Y chromosome are female	1
Possible:	8
Maximum:	6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-ER.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: ER
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3.
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:
KEYWORDS: Mendel's laws, test cross.	

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid crosses.

Item Focus

Same as above.

Item

In a cross between two strains of corn, ears of corn resulted in which yellow and purple kernels occurred in the ratio of 1:1. Explain the results of this cross in terms of Mendel's laws. Assume that purple colour is dominant over yellow.

Response/Marking Scheme

To produce a 1:1 ratio, the plants that were crossed must have been one heterozygous for colour, and the other homozygous recessive. 2

Let the allele for purple be represented by P. Then the allele for yellow will be represented by p. 1

Then the parents were:

	Heterozygous purple	×	homozygous yellow	2
Genotypes:	Pp	×	pp	1
Gametes:	P or p	×	p or p	1

Punnett square: 2

	p	p
P	Pp	Pp
p	pp	pp

Thus the offspring will be

50% purple, heterozygous (Pp), and
50% yellow, homozygous (pp). 2

Mendel's Law of Dominance

- whenever one of the dominant alleles is present, the offspring will show that trait. Thus all individuals with one or more P alleles will have the phenotype purple. To appear yellow, an individual must have both recessive alleles. 2

Mendel's Law of Segregation

- when sister gametes are formed, only one determiner (gene) for each trait passes into each gamete. Thus in forming the Punnett square, only one allele from each pair reaches the offspring. 2

Possible: 15

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Meiosis
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-SA.01R
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3.A.5, D.1
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: meiosis genetic variability

Guideline Objective

The student will describe the stages of meiosis and its role in diploid organisms.

Item Focus

The student should be able to recognize and reconstruct the stages of meiosis from microscopic observations.

Item

Refer to Figure 4(8).4 to answer this question.

The diagrams accompanying this question show the distribution of DNA in eleven different cells of the same species at different stages of meiosis. On your answer page, print the numbers from 1 to 11 on alternate lines. Opposite each number, print the letter of one of the diagrams so that the stages of meiosis will appear in sequence from the earliest (#1) to the latest (#11). Finally, after each letter, write a single sentence or phrase to indicate the most significant event that has occurred during that phase.

Response/Marking Scheme

Note: Allow 1 mark for each phase placed in the correct sequence, and a second mark for correctly describing each phase.

1. F - chromatin begins to condense
2. B - double-stranded chromosomes become visible
3. H - homologous chromosomes line up beside each other
4. J - pairs of homologous chromosomes attach to the spindle at cell equator
5. K - homologs separate and are pulled along spindle to opposite poles
6. D - homologs gather at the poles
7. C - chromosomes begin to disperse again
8. I - chromosomes line up at cell equators
9. G - monad chromosomes move towards poles of cells
10. E - chromosomes gather at the poles (4 cells)
11. A - chromosomes are dispersing into chromatin nets

Possible: 22

Maximum: 22

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Mendelian Genetics
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: multiple alleles blood types

INSTRUMENT CODE: B048a-SA.02
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics.

Item Focus

The student will develop skill in using a Punnett square to solve problems involving multiple alleles.

Item

A couple have children of blood groups A and AB. This couple cannot have children of blood groups O or B.

A. What are the possible genotypes of the couple?

B. Write out the possible crosses involved.

Response/Marking Scheme

A. If I^A represents the allele for antigen A, and I^B represents the allele for antigen B, and i represents the recessive allele, then the parents may have been I^AI^A and I^Bi, or 2
I^AI^A and I^AI^B. 2

B.

	Cross 1	Cross 2	
	$I^AI^A \times I^Bi$	$I^AI^A \times I^AI^B$	
gametes:	$I^A \times I^B$	$I^A \times I^A$ or I^B	
OFFSPRING:	I^AI^B or I^Ai	I^AI^A or I^AI^B	2
Blood groups:	AB or A	A or AB	2

Possible: 8

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.7, A.10
TOPIC: Review of Sex-linked Traits	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: sex-linked trait genetic mosaic

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving sex linkage.

Item Focus

Same as above.

Item

The black and yellow pigments in the coats of cats are controlled by a sex-linked pair of alleles, located on the X-chromosome. The "tortoise shell" or "calico" cat is the heterozygous condition. In answering the following questions, use B to represent the black allele, and Y for the yellow allele.

A. What are the genotypes of the following cats?

1. A yellow female.
2. A yellow male.
3. A black female.
4. A black male.
5. A calico.

B. A calico cat has a litter of 8 kittens: 1 yellow male, 2 black males, 2 yellow females, and 3 calico females. Assuming a single father, what was his colour? With the aid of a diagram, showing parents, gametes, Punnett square, and offspring, explain the cross.

Response/Marking Scheme

A. 1. X^YX^Y — 1
2. X^YY — 1
3. X^BX^B — 1
4. X^BY — 1
5. X^BX^Y — 1

B. Since there are yellow females in the litter, the father must have been yellow. — 1

Parents:	calico female	×	yellow male	1
	X^BX^Y	×	X^YY	1
Gametes:	X^B or X^Y		X^Y or Y	

Punnett square:

	X^B	X^Y
X^Y	X^BX^Y	X^YX^Y
Y	X^BY	X^YY

2

Offspring:	1 calico female	: 1 yellow female	: 1 black male	: 1 yellow male		1
	X^BX^Y	X^YX^Y	X^BY	X^YY		1
Given ratio:	3	: 2	: 2	: 1		

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Mendelian Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-SA.04
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A..2, A.4, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: dihybrid homozygous genotype phenotype

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving dihybrid crosses.

Item Focus

The student should be able to solve problems involving dihybrid crosses.

Item

Normal pigmentation of the human skin (gene N) is dominant over albino pigmentation (n). Normal hearing (H) is dominant over deafness (h). An albino man homozygous for normal hearing marries a deaf woman homozygous for normal pigmentation.

A. State the genotypes of this man and woman.

B. What phenotypes and genotypes can be expected in their children?

C. If a son from this marriage marries a woman with the same genotype as himself, what are the possible genotypes of their children? State the ratio of these phenotypes.

Write out each cross fully, showing the phenotypes of the parents and the offspring, and the genotypes of the parents, gametes, and offspring. Use a Punnett square.

Response/Marking Scheme

A. Genotype of the man: nnHH; of the woman: NNhh 2

B. Dihybrid cross:

Parents: nnHH × NNhh 1

Gametes: nH Nh 1

F_1 offspring: all NnHh 1

Phenotype: all normal for pigment and hearing 1

Genotype: all fully heterozygous for pigment and hearing. 1

C. F_1 parents: NnHh × NnHh 1

Gametes: NH or Nh or nH or nh for both parents 1

Punnett square: 2

	NH	Nh	nH	nh
NH	NNHH	NNHh	NnHH	NnHh
Nh	NNHh	NNhh	NnHh	Nnhh
nH	NnHh	NnHh	nnHH	nnHh
nh	NnHh	Nnhh	nnHh	nnhh

The possible ratio of the F_2 Offspring:

9 normally pigmented, normal hearing 1

3 normally pigmented, deaf 1

3 albino, with normal hearing 1

1 albino, deaf 1

Possible: 15

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.4, A.10
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: dihybrid homozygous phenotype genotype

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving a dihybrid cross.

Item Focus

The student should be able to solve a problem involving a dihybrid cross.

Item

In a certain species of plant, scented and odourless flowers occur, together with hairy and smooth stems. A scented, smooth-stemmed plant was crossed with a fully homozygous odourless plant with hairy stems. This cross produced four kinds of phenotypes among the offspring, in equal numbers (i.e., a ratio of 1:1:1:1).

Write the cross out fully, including in your answer:

A. the descriptions of the phenotypes of the parents and offspring,

B. the genotypes of the parents, gametes and offspring,

C. a Punnett square.

D. Briefly explain your reasoning.

Response/Marking Scheme

A. and B.

Parents:

Scented, smooth × odourless, hairy

SsDd × ssdd 2

Gametes:

SD or Sd or sD or sd × sd 1

C. Punnett square:

	SD	Sd	sD	sd
sd	SsDd	Ssdd	ssDd	ssdd

4

(which is the given ratio.) 1

Offspring:

1 SsDd	: 1 Ssdd	: 1 ssDd	: 1 ssdd
scented	scented	odourless	odourless
smooth	hairy	smooth	hairy

D. Since the fully homozygous plant can only produce one kind of gamete, and 1

since the ratio of the offspring was 1:1:1:1, 1

the scented smooth-stemmed plant must have produced four kinds of gametes, and must 1

have been fully heterozygous. 1

Thus the dominant genes must be scented (S) and smooth-stemmed (D); 1

and the recessive genes odourless (s), and hairy (h). 1

Possible: 14

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.4, A.10
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: dihybrid dominant phenotype genotype homozygous

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving a dihybrid cross.

Item Focus

The student should be able to solve a problem involving a dihybrid cross.

Item

In cattle, hornless (gene D) is dominant over horned (gene d), and black (B) is dominant over roan (b). What will the expected offspring be from matings between hornless black bulls, homozygous for both traits, and horned, roan cows?

A herd of cattle resulted from the matings of the F1 offspring of the cross described above. If 36 of them were hornless black, how many horned black cattle should there have been, assuming a perfect ratio?

Write out the crosses involved, giving the phenotypes of the parents and offspring, and the genotypes of the parents, gametes and offspring. Use a Punnett square for the second cross.

Response/Marking Scheme

P_1 generation:

hornless black bull × horned roan cow

DDBB × ddbb 2

Gametes: DB × db 1

F_1 genotype: DdBb 1

phenotype: all hornless, black 1

These serve as parents for the second cross.

DdBb × DdBb

Possible gametes from each parent:

DB or Db or dB or db 1

Punnett square: 2

	DB	Db	dB	db
DB	DDBB	DDBb	DdBB	DdBb
Db	DDBb	DDbb	DdBb	Ddbb
dB	ddBB	DdBb	ddBB	ddBb
db	DdBb	Ddbb	ddBb	ddbb

F_2 Thus the offspring are:

9 hornless black : 3 horned black : 3 hornless roan : 1 horned roan 2

But 36 were hornless black (9 × 4)

therefore, 4 × 3 or 12 should have been horned black. 1

Possible: 11

Maximum: 9

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.07R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A1, A2, C3, D1, D3
TOPIC: Review of Population Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: significance Chi square test sex-linked inheritance

Guideline Objective

The student will solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics.

Item Focus

The student should be able to determine if the results of an experiment are significant and were thus obtained by chance alone.

Item

Refer to Figure 4(8).5a and Figure 4(8).5b. Figure a

x^2 TABLE									
DEGREES OF FREEDOM	PROBABILITY								
	.95	.90	.80	.70	.50	.30	.10	.05	.01
1	.004	.016	.064	.148	.455	1.07	2.71	3.84	6.64
2	.103	.211	.446	.713	1.38	2.41	4.60	5.99	9.2
3	.352	.584	1.00	1.42	2.37	3.66	6.25	7.82	11.3
degrees of freedom = number of classes −1									

Figure b

	1	2	3	4	Total
Phenotype Class	+	white-eye	+	white-eye	
Number of Individuals	A_1	A_2	A_3	A_4	
Expected Number	E_1	E_2	E_3	E_4	

$$x^2 = \frac{(A_1 - E_1)^2}{E_1} + \frac{(A_2 - E_2)^2}{E_2} + \frac{(A_3 - E_3)^2}{E_3} + \frac{(A_4 - E_4)^2}{E_4}$$

Four female wild Drosophila (homozygous) were crossed with four male white-eyed Drosophila. The F_1 progeny were then allowed to interbreed and the following phenotypes for the F_2 generation were obtained:

Female wild	199
Male wild	797
Male white-eyed	112

A. What mode of inheritance is this?

B. Use the x^2 table (Figure 4(8).5a) and Figure 4(8).5b to determine whether or not the results are significant. Submit a completed data table (Figure 4(8).5b) as part of your answer.

Response/Marking Scheme

A. The mode of inheritance exhibited by this problem is sex-linked.

B.

	1	2	3	4	Total	
Phenotype Class	+	white-eye	+	white-eye		4
Number of Individuals	A_1 199	A_2 0	A_3 97	A_4 112	408	
Expected Number	E_1 204	E_2 0	E_3 102	E_4 102	408	

$$x^2 = \frac{(A_1 - E_1)^2}{E_1} + \frac{(A_2 - E_2)^2}{E_2} + \frac{(A_3 - E_3)^2}{E_3} + \frac{(A_4 - E_4)^2}{E_4}$$

$$= \frac{(199 - 204)^2}{204} + 0 + \frac{(97 - 102)^2}{102} + \frac{(112 - 102)^2}{102} \quad 3$$

$$= 1.351 \quad 1$$

Degrees of Freedom $= n - 1 = 4 - 1 = 3$ 1

The probability of replicating these results is 70%. 1

The results are significant. 1

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Mendelian Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-SA.08
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.4, A.5, A.7, C.1, C.2
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: multiple alleles blood types

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics.

Item Focus

The student should be able to relate the genetics and physiology of cross matching blood for transfusions.

Item

It is the second pregnancy of a mother who has Type A blood. The fetus is showing signs of distress, and may need a transfusion at birth. The following pedigree shows the blood types of the family.

Grandparents	MATERNAL	PATERNAL
	O Rh^+ A Rh^+	A Rh^+ B Rh^+
Parents	MOTHER	FATHER
	A Rh^-	B Rh^+
Children	O Rh^+	??

A. Why might the baby need a transfusion at birth?

B. What are the probabilities for the blood type of the fetus?

C. Which members of the family can possibly donate blood to the newborn?

Note: the alleles for the blood groups are as follows:

BLOOD GROUP	A	B	AB	O	Rh^+	Rh^-
ALLELES	I^AI^A, I^AI^O	I^BI^B, I^BI^O	I^AI^B	I^OI^O	RR, Rr	rr

Response/Marking Scheme

A. At the end of the first pregnancy, some of the fetal blood containing the Rh^+ antigen mixed with the mother's blood, 1

sensitizing the mother to produce anti-Rh antibodies. 1

Hemorrhaging during the second pregnancy allows the anti-Rh antibodies to agglutinate the fetal blood. 1

B.

	MOTHER	FATHER	
PHENOTYPE:	A Rh^-	O Rh^+	
GENOTYPE:	I^A i	ii RR or Rr	1
GAMETES:	I^A r, i ri R, or i r		2

PUNNETT SQUARE: 4

	i R	i r
I^A r	I^Ai Rr	I^Ai rr
i r	ii Rr	ii rr

The probabilities are: 1 in 4 (25%) for each of the following phenotypes:

A Rh^+, O Rh^+,
A Rh^-, O Rh^- 2

C. If the baby is A Rh^-, the mother can donate. But this is unlikely, since the fetus shows distress.

If the baby is O Rh^+, either the father or the maternal grandmother can donate. 1

If the baby is A Rh^+, either of the maternal grandparents or the paternal grandmother can donate. 1

If old enough to donate blood, the first child can donate to a Rh^+ sibling. 1

Possible: 15

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Mendelian Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-SA.09
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.4, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: genotype phenotype heterozygous homozygous

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics.

Item Focus

The student should be able to solve a problem involving a monohybrid cross.

Item

In certain mice, the recessive form of a trait is grey. A mouse heterozygous for this trait is yellow. The homozygous dominant form dies while still an early embryo.

A. What offspring would be expected from the following crosses?

1. A yellow mouse is crossed with a grey mouse.
2. Two yellow mice are crossed.

B. From which of these crosses would you expect the larger litter?

Include in your answers the phenotypes of the parents and offspring, and the genotypes of parents, gametes, and offspring. Use the symbol D for the dominant allele, and d for the recessive allele.

Response/Marking Scheme

A.

Let the grey mouse be represented by dd,
and the yellow mouse by Dd,
while the stillborn embryo is DD. 3

1. Parents: Yellow × Grey
   Dd × dd
   Gametes: D or d × d
   Offspring: Dd and dd in a ratio of 1:1
   Yellow and Grey 3

2. Parents: Yellow × Yellow
   Dd × Dd
   Gametes: D or d D or d

Offspring: DD 2 Dd dd
Ratio: 1 : 2 : 1

But DD dies stillborn, leaving a ratio of 2:1
2 Yellow : 1 grey 3

B.

The first cross should result in a larger litter, 1
since none of the embryos die, whereas in the 1
second cross, one quarter of the embryos die. 1

Possible: 12

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.4, A.10
TOPIC: Review of Mendelian Genetics	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: backcross monohybrid phenotype genotype

Guideline Objective

The student will develop skill in using a Punnett square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics.

Item Focus

The student should be able to solve a problem concerning a monohybrid cross.

Item

When a white ram was mated with black ewes, it sired only white lambs. When this ram was mated with a certain white ewe, all the lambs were white. When one of these lambs reached maturity, it was backcrossed with its mother, which produced a black lamb. Account for these results by making diagrams of each of the crosses mentioned, including the genotypes of the parents, gametes and offspring, and the phenotypes of the parents and offspring.

Response/Marking Scheme

Since the white ram × black ewes produced only white lambs,

the white trait must be dominant,	1
and the white ram must be homozygous.	1

Let the allele for whiteness be W, and for blackness be w. 1

Cross 1:		white ram	×	black ewe	
		WW	×	ww	1
	Gametes:	W	×	w	1
	Offspring:	Ww, all white lambs.			1
Cross 2:		white ram	×	a certain white ewe	
		WW	×	Ww	1
	Gametes:	W	×	W or w	1
	Offspring:	WW or Ww, 1:1 ratio, all white			1
Cross 3:		white ram	×	a certain white ewe	
		Ww	×	Ww	1
	Gametes:	W or w	×	W or w	1

Punnett square:

	W	w
W	WW	Ww
w	Ww	ww

Offspring: 1 WW : 2 Ww : 1 ww
3 white lambs : 1 black lamb 1

Possible: 12

Maximum: 12

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Population Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-SA.11
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.5, A.8, C.1, D.1, F.1

DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: probability

Guideline Objective

The student will develop skill in using probability laws to predict the results of crosses, e.g., the probability of two events occurring in a specific order, such as having a boy, girl, girl, boy in that order, or having two boys and two girls in any order.

Item Focus

The student should be able to predict the probability of a male child.

Item

A family has four boys, and the mother is expecting a fifth child. What is the probability that this child will be male?

Response/Marking Scheme

Probability = 0.5, because with each child the probability remains the same. 2

Possible: 2

Maximum: 2

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Population Genetics
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B048a-SA.12
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.5, A.8, C.1, D.1, F.1

DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: probability

Guideline Objective

The student will develop skill in using probability laws to predict the results of crosses, e.g., the probability of two events occurring in a specific order, such as having a boy, girl, girl, boy in that order, or having two boys and two girls in any order.

Item Focus

The student should be able to predict the probability of all the children in a family being of the same sex.

Item

A family has five children, all boys. What is the probability of a family having five children of the same sex?

Response/Marking Scheme

The separate probability that each child will be of the same sex is 0.5. 1

The probability of five males is $(0.5)^5 = 0.031$

(This could also be expressed as $\frac{1}{2^5} = \frac{1}{32}$)

Possible: 2

Maximum: 2

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Meiosis
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: meiosis genetic variability

INSTRUMENT CODE: B048a-SA.14
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

Guideline Objective

The student will describe two ways in which meiosis increases genetic variability in gametes.

Item Focus

Same as above.

Item

A. State two ways in which meiosis gives rise to genetic variation.

B. State the possible genotypes of the gametes that could result from meiosis of a cell with the genotype AabbCc.

Response/Marking Scheme

A.

1. In meiosis, chromosomes are reduced to one half as members of each homologous pair are sorted into sister gametes. Thus each gamete contains assortments of chromosomes that may not have existed before. 3
2. In meiosis, the chromatids of homologous chromosome undergo crossing over. Parts of one chromatid are exchanged with corresponding parts of another, resulting in new combinations of genes on the chromosomes of sister gametes. 3

B.

Abc, AbC, abc, abC. 4

Possible: 10

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Cellular Genetics
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: gametogenesis

INSTRUMENT CODE: B048a-SA.15
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.6.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

Guideline Objective

The student will compare gametogenesis in male and female animals.

Item Focus

As above.

Item

Complete the following table, comparing gametogenesis in male and female animals by writing a word or short phrase in each space.

COMPARISON	MALE GAMETOGENESIS (SPERMATOGAMETOGENESIS)	FEMALE GAMETOGENESIS (OOGENESIS)
Site of occurrence		
Number of gametes from one stem cell		
Name of the gamete		
Relative size of gametes		
One special adaptive structure of the gamete		

Response/Marking Scheme

COMPARISON	MALE GAMETOGENESIS	FEMALE GAMETOGENESIS
Site of occurrence	testis, or seminiferous tubule	ovary, or Graffian follicle 2
Number of gametes from one stem cell	4	1 2
Name of the gamete	sperm	ovum (egg) 2
Relative size of gametes	small	large 2
One special adaptive structure of the gamete	flagellum, or acrosome, or concentration of mitochondria in the tail	cortical granules, or chemical attractants, or membrane structure 2

Possible: 10

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.16
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 413n
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.2, A.4, A.10
TOPIC: Review of Dihybrid Crosses	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: phenotype genotype homozygous Punnett square dihybrid

Guideline Objective

The student should be able to solve a problem involving a dihybrid cross, using a Punnett square.

Item Focus

Same as above.

Item

When a homozygous tall plant with red flowers is crossed with a short plant bearing white flowers, what will the the phenotypes of the offspring be for the next two generations? Describe the cross fully showing symbolic genotypes of the P_1 and P_2 generations, the gametes, and the F_1 and F_2 offspring. Include a Punnett square in your answer.

Note: In this species, tallness (T) is completely dominant over shortness (t). A red (R^1) flower, crossed with a white (R^2) flower produces pink (R^1R^2) flowers.

Response/Marking Scheme

P^1 (parents):	homozygous tall plant with red flowers	×	short plant with white flowers	
	TTR^1R^1	×	ttR^2R^2	2
Gametes:	TR^1	×	tR^2	2
F^1 genotype:	TtR^1R^2			1
phenotype:	all tall plants with pink flowers			2

P^2 are the F^1 offspring: tall plants with pink flowers,

TtR^1R^2 × TtR^1R^2 2

Gametes: TR^1 or TR^2 or tR^1 or tR^2 for each parent 2

Punnett square: 4

	TR^1	TR^2	tR^1	tR^2
TR^1	TTR^1R^1	TTR^1R^2	TtR^1R^1	TtR^1R^2
TR^2	TTR^1R^2	TTR^2R^2	TtR^1R^2	TtR^2R^2
tR^1	TtR^1R^1	TtR^1R^2	ttR^1R^1	ttR^1R^2
tR^2	TtR^1R^2	TtR^2R^2	ttR^1R^2	ttR^2R^2

F^2 offspring, phenotype ratio: 6

3 tall red : 6 tall pink : 3 tall white : 1 short red : 2 short pink : 1 short white

Possible: 21

Maximum: 15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 04
UNIT NAME: GENETICS
TOPIC: Review of Autosomal Linkage
CURRICULAR EMPHASIS: Solid Foundations
KEYWORDS: crossing over heterozygous dihybrid

INSTRUMENT CODE: B048a-SA.17
GUIDELINE OBJECTIVE CODE: 48a
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.10, D.3, D.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

Guideline Objective

The student will be expected to explain the results of a cross involving autosomal crossing over.

Item Focus

Same as above.

Item

A grey, normal-winged fruit fly, heterozygous for both body colour and wing development (GgNn), was crossed with a black-bodied, vestigial-winged fly. The following offspring were obtained:

grey-bodied, normal-winged	14
grey-bodied, vestigial-winged	133
black-bodied, normal-winged	137
black-bodied, vestigial-winged	16.

A. Explain why this result indicates autosomal linkage.

B. What percentage of alleles crossed over?

C. With the aid of diagrams, explain the crosses, indicating which trait was involved in crossing over. Show the distribution of the alleles on the parental chromosomes, in the gametes, and in the offspring.

Since the given ratio, 133:137, is almost exactly 1:1, this trait was not involved in crossing over. 1

Possible: 20

Maximum: 15

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.18
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A. 10, D.3. D.6
TOPIC: Biochemical Genetics	
CURRICULAR EMPHASIS: Solid Foundations	DIFFICULTY LEVEL: H
	TIME ALLOCATION:

KEYWORDS: phenotype dihybrid Punnett square

Guideline Objective

The student will be expected to explain the results of a cross involving autosomal crossing over.

Item Focus

The student should be able to interpret the results of a dihybrid cross to make conclusions about autosomal linkage.

Item

When tall tomato plants with red fruit were crossed with dwarf plants bearing yellow fruit, all of the offspring were tall plants with red fruit. When these F_1 plants were crossed, only two phenotypes appeared in the next (F_2) generation.

Using T to represent the allele for tallness, and R to represent the allele for redness, write out the details of the crosses, showing the genotypes of the parents, gametes, and offspring, and using Punnett squares.

Make four conclusions regarding the genetic control of these two traits, and give reasons for your conclusions.

Response/Marking Scheme

First conclusion: Since all the F_1 generation were tall with red fruit, tallness and redness are completely dominant over dwarfness and yellowness, and 2
the tall red plants must have been homozygous for both traits. 1

Second conclusion: Since only two phenotypes occur in the F_2 generation, these trait must be linked on the same chromosome (autosomal linkage). 2

Let the allele for tallness be represented by T,
and the allele for dwarfness by t,
let the allele for redness be represented by R,
and the allele for yellowness by r. 2
Let $\widehat{\ }$ symbolize linkage.

P_1	Tall, red fruit	×	Dwarf, yellow fruit	
	$\widehat{TR}\widehat{TR}$	×	$\widehat{tr}\widehat{tr}$	1
Gametes	$\widehat{TR}$	×	$\widehat{tr}$	1
F_1 offspring		all $\widehat{TR}\widehat{tr}$		1
	all heterozygous for both traits, with phenotype Tall, red fruit.			
P_2 parents (F_1)	$\widehat{TR}\widehat{tr}$	×	$\widehat{TR}\widehat{tr}$	1
Gametes	$\widehat{TR}$ or $\widehat{tr}$	×	$\widehat{TR}$ or $\widehat{tr}$	1

Punnett square: 1

	$\widehat{TR}$	$\widehat{tr}$
$\widehat{TR}$	$\widehat{TR}\widehat{TR}$	$\widehat{TR}\widehat{tr}$
$\widehat{tr}$	$\widehat{TR}\widehat{tr}$	$\widehat{tr}\widehat{tr}$

F_2 offspring:

1 $\widehat{TR}\widehat{TR}$: 2 $\widehat{TR}\widehat{tr}$: 1 $\widehat{tr}\widehat{tr}$ 1

3 tall, red fruit : 1 dwarf, yellow fruit 1

Third Conclusion: Since only two phenotypes appear in the F_2 generation, there must have been no crossing over. 1

Fourth Conclusion: Since there was no crossing over, the genes for the two traits must be very close on the same chromosome. 1

Possible: 17

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.19
LEVEL: OAC	GUIDELINE OBJECTIVE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.3, A.10
TOPIC: Review of Population Genetics	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: homozygous crossing over phenotype

Guideline Objective

The student should be able to predict the expected ratios of offspring following particular crosses involving autosomal linkage.

Item Focus

Same as above.

Item

For each of the following crosses, explain with the aid of diagrams the genotypes of the parents, gametes, and offspring. Use Punnett squares where appropriate.

A. A homozygous, grey bodied, long winged fruit fly ($\widehat{\text{GN}}\widehat{\text{GN}}$) was crossed with a black, vestigial winged fly ($\widehat{\text{gn}}\widehat{\text{gn}}$). (The mark indicates linked genes.) Assuming that no crossing over occurs, what ratios of phenotypes would you expect in the F_1 and F_2 generations?

B. If a fruit fly from the F_1 generation above were backcrossed to a black, vestigial winged fly, what phenotypic ratio would you expect, assuming no crossing over?

C. If the offspring of the backcross in part B above consisted of 400 flies, and if crossing over occurred in 10% of the cases, what ratio of phenotypes would you expect in the offspring?

Response/Marking Scheme

A.

P_1	homozygous grey, long winged	×	homozygous black, vestigial winged	
	$\widehat{GN}\widehat{GN}$	×	$\widehat{gn}\widehat{gn}$	1
gametes:	$\widehat{GN}$	×	$\widehat{gn}$	1
F_1 offspring:	all $\widehat{GN}\widehat{gn}$			
Phenotype:	all grey with long wings			1
P_2 (F_1):	$\widehat{GN}\widehat{gn}$	×	$\widehat{GN}\widehat{gn}$	1
gametes:	$\widehat{GN}$ or $\widehat{gn}$	×	$\widehat{GN}$ or $\widehat{gn}$	1

Punnett square: 1

	$\widehat{GN}$	$\widehat{gn}$
$\widehat{GN}$	$\widehat{GN}\widehat{GN}$	$\widehat{GN}\widehat{gn}$
$\widehat{gn}$	$\widehat{GN}\widehat{gn}$	$\widehat{gn}\widehat{gn}$

F_2 offspring: 1 $\widehat{GN}\widehat{GN}$: 2 $\widehat{GN}\widehat{gn}$: 1 $\widehat{gn}\widehat{gn}$

Phenotypes: 3 grey,long wings : 1 black,vestigial 1

B. Backcross:

P_1 F_1	fruit fly	×	black, vestigial	
	$\widehat{GN}\widehat{gn}$	×	$\widehat{gn}\widehat{gn}$	1
Gametes:	$\widehat{GN}$ or $\widehat{gn}$	×	$\widehat{gn}$	1

Assuming no crossing over,

F_2 offspring: 1 $\widehat{GN}\widehat{gn}$: 1$\widehat{gn}\widehat{gn}$

Phenotypes: 1 grey,long wing : 1 black,vestigial 1

C.

In 400 offspring, with 10% crossing over, there would be 90% with NO crossing over. From Part B, the ratio of these 360 offspring would be:1

180 grey, long winged : 180 black, vestigial 1

For the 40 offspring in which crossing over occurred,

P_2	$\widehat{\text{Gng}}\widehat{\text{N}}$	×	$\widehat{\text{gngn}}$	1
Gametes:	$\widehat{\text{Gn}}$ or $\widehat{\text{gN}}$	×	$\widehat{\text{gn}}$	1
F_2 Offspring:	1 $\widehat{\text{Gngn}}$: 1 $\widehat{\text{gNgn}}$			1

Phenotypes: 20 grey, vestigial : 20 black, long 1

Therefore, among the 400 offspring of the backcross, the phenotypic ratio is

180 grey long winged	:	180 black vestigial	:	20 grey vestigial	:	20 black long winged	1

Possible: 17

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B048a-SA.20
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 48a
UNIT NUMBER: 04	INSTRUMENT TYPE: SA
UNIT NAME: GENETICS	KLOPFER: A.1, A.2, A.7, A.9
TOPIC: Review of Population Genetics	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: testcross dihybrid linkage

Guideline Objective

The student will explain the results of a dihybrid cross such as AaBb × AaBb where the chromosomes are linked on the same chromosome.

Item Focus

Same as above.

Item

A test cross involved autosomal linked traits whose alleles were A or a and B or b. Explain the fact that a dihybrid test cross of these alleles produced the same ratio of offspring as would be expected in a Mendelian (non-linked) testcross. Write out both the Mendelian cross and the autosomal linked cross as part of your answer.

Response/Marking Scheme

Mendelian test cross:

fully heterozygous x fully homozygous recessive	1
AaBb × aabb	1
AB or Ab or aB or ab × ab	1
1 AaBb: 1 Aabb: 1 aaBb: 1 aabb	1
Ratio of offspring is 1:1:1:1	1

Autosomal linked test cross

Assume linkage:

$\widehat{AB}\widehat{ab} \times \widehat{ab}\widehat{ab}$	1
$\widehat{AB}$ or $\widehat{ab} \times \widehat{ab}$	1
1 $\widehat{AB}\widehat{ab}$: 1 $\widehat{ab}\widehat{ab}$	1
Ratio is 1:1	1

Assume linkage:

$\widehat{Ab}\widehat{aB} \times \widehat{ab}\widehat{ab}$	1
$\widehat{Ab}$ or $\widehat{aB} \times \widehat{ab}$	1
1 $\widehat{Ab}\widehat{ab}$: 1 $\widehat{aB}\widehat{ab}$	1
Ratio is 1:1	1

Given that the two ratios of offspring

i.e., Mendelian 1:1:1:1 and
autosomal linked, 1:1 and 1:1

are the same,	1
this means that the two gene loci must be far enough apart on the chromosomes to ensure 100% cross over	2
which would lead to 50% parental type gametes (non-cross over)	1
and 50% recombinant type gametes (cross over)	1
giving the same ratio of gametes as in the Mendelian cross.	1
Possible:	19
Maximum:	15

Teacher Notes

Min Gu OAC biology : optional
574. unit IV : genetics
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059bi
Unit